K
HD
1694
03
A6

ANNEX
LIBRARY
B
085590

ENGINEERING
TD
1694

ANNEX
LIBRARY
B
085590

Cornell University Library
Ithaca, New York

THE LIBRARY OF
EMIL KUICHLING, C. E.
ROCHESTER, NEW YORK

THE GIFT OF
SARAH L. KUICHLING
1919

Engineering

Cornell University Library
HD 1694.O3A6

Fourth report of an investigation of the

3 1924 004 462 820 engr, anx

Cornell University Library

The original of this book is in
the Cornell University Library.

There are no known copyright restrictions in
the United States on the use of the text.

http://www.archive.org/details/cu31924004462820

FOURTH REPORT OF AN INVESTIGATION

OF

THE RIVERS OF OHIO

AS SOURCES OF PUBLIC WATER SUPPLIES.

BY THE OHIO STATE BOARD OF HEALTH.

1901.

REPRINTED FROM THE FIFTEENTH ANNUAL REPORT OF THE
OHIO STATE BOARD OF HEALTH.

ALLIED PRINTING
TRADES UNION LABEL COUNCIL
COLUMBUS O

COLUMBUS, OHIO,
FRED. J. HEER, STATE PRINTER.
1902.

FOURTH REPORT UPON THE EXAMINATION OF SOURCES OF PUBLIC WATER SUPPLIES.

This special report deals with an examination of the two Miami rivers, in continuation of an investigation of the condtion of sources of public water supplies begun in 1897. This completes the investigation for all the interior streams. Another year will be required for a study of the water supplies of the Ohio River and Lake Erie, which will finish the work.

The two Miamis drain the most elevated, and, in some aspects, the most beautiful portion of the state. With a total drainage area of 6,950 square miles, of which 5,601 square miles are in Ohio, they both discharge their waters into the Ohio River near Cincinnati.

The population of the two watersheds — census of 1900 — is 641,657, or 92 persons per square mile. Excluding that part of the watershed of the Great Miami lying in Indiana and the population upon it, the average population is a little higher — 100 persons per square mile of watershed. This is slightly below the average for the state.

Batavia and Piqua are the only communities within this territory that depend entirely upon these rivers (their tributaries) for a water supply. Batavia has installed a mechanical filter to purify its supply, and is reasonably free from danger from polluted water. Piqua obtains water from a feeder for the Miami and Erie canal. The water is not considered fit for domestic use, and is but little, if at all, used for that purpose.

Blanchester makes up a deficiency in its well supply in using the impounded waters of a small creek. Both the well and surface waters are of inferior quality.

Springfield has ordinarily a ground water supply, but in dry years has resorted to Buck Creek for an additional supply. The creek water is not suitable for domestic use, and Springfield must soon make suitable provision for increasing its present insufficient supply.

Thirty cities and villages within the territory under consideration have public water supplies. The combined population so furnished is 242,762, which is 44 per cent. of the entire population, and 91 per cent. of the urban population, as here classified. There are six villages of less than 1,000 inhabitants that have water works, and 18 urban towns (over 1,000 population) without water works and still dependent upon private wells. Miamisburg and Wilmington, each with nearly 4,000 population, are in this list. More than half of the water works in this territory have been installed since 1890. The 25 plants that have been completed cost $4,352,805, with a per capita cost varying from 8 to 32 dollars. The average daily supply of water for 20 plants for which information could be obtained was 67 gallons per capita of the total population, and 116 gallons per consumer. In the engineer's report may be found some interesting data in regard to rates charged for water by the different municipalities and companies operating water works. A detailed report is also given of the various sources of pollution of the rivers under consideration. It will be noted that there are a considerable number of strawboard works and paper mills discharging their wastes into these streams. This has already caused a nuisance in some places, and started litigation for the abatement thereof.

Of the 29 cities and villages having water works 15, including Hyde Park, have more or less extensive sewerage systems. In all instances the sewage is discharged to streams without purification. The estimated number of closet connections to these sewers is 4,197, and about 14 per cent. of the total population are using the sewers. About 50 per cent. of the population having access to the sewers make use of them.

While no public water supplies in Ohio, except that of Cincinnati, are affected to much extent by the sewage discharged into the Miami rivers, more or less nuisance has already been caused in thirteen different places by sewage pollution. Many of these communities must face the problem of sewage purification in the near future. The city of Xenia is to be congratulated for having provided for sewage purification works to be constructed in conjunction with a new system of sewers.

A source of pollution of streams too frequently lost sight of or but lightly considered, is the sewage from public institutions. Within the watersheds of the two Miamis there is a population of 531 in Childrens' Homes, 1,509 in County Infirmaries and 8,151 in other public institutions, including the Soldiers' Home at Dayton and the Ohio Soldiers' and Sailors' Orphans' Home at Xenia. This gives a total population of 10,191, nearly all using sewered closets that discharge into streams, so that the public institutions are responsible for nearly one-third as much sewage as are all the cities and villages on both watersheds.

As pointed out in the engineer's report, "In not a single instance does it seem necessary to pollute the streams with sewage from these institutions. Everything is favorable to the installation of some method of purification; the sewerage is small in amount, usually in a concentrated form; it is collected in one outfall sewer; in nearly every case land is plentiful and usually labor can be had at small or no extra expense." The commissioners of Montgomery county deserve credit for having recently constructed a very satisfactory system of sewage disposal for the infirmary of that county.

Supplementary to the survey of the two watersheds to determine the origin and nature of the various pollutions of the rivers, monthly chemical and bacteriological examinations of samples of water taken from the rivers at twenty-nine different places were made for a period of eight months. A detailed report of the findings may be found in the report of the chemist and bacteriologist. These results agree very well, as regards the character of these waters, with the conclusions to be reached from a study of the engineer's report. Neither river is grossly polluted, except some of their small tributaries, but neither in any part of its course would furnish water suitable for domestic purposes without purification.

The Little Miami River is objectionable in appearance, has a noticeable odor at all times, and carries considerable sediment. It is now receiving in many places the full amount of decomposable matters that can be harmlessly disposed of by natural processes.

The Great Miami River also carries considerable sediment, and clear waters are rarely to be found. The main stream is still able to maintain a sufficient degree of purification to prevent nuisances from bad odors, but in addition to large quantities of vegetable matters it is called upon to receive and purify, the sewage of towns and wastes of factories poured into it which have already reached proportions that make it impossible for it to regain at any point the degree of purity possessed by its head waters.

It would be a wise policy for the communities contributing to the pollution of these streams to give early consideration to the question of measures to preserve them from further damage.

PLATE 2

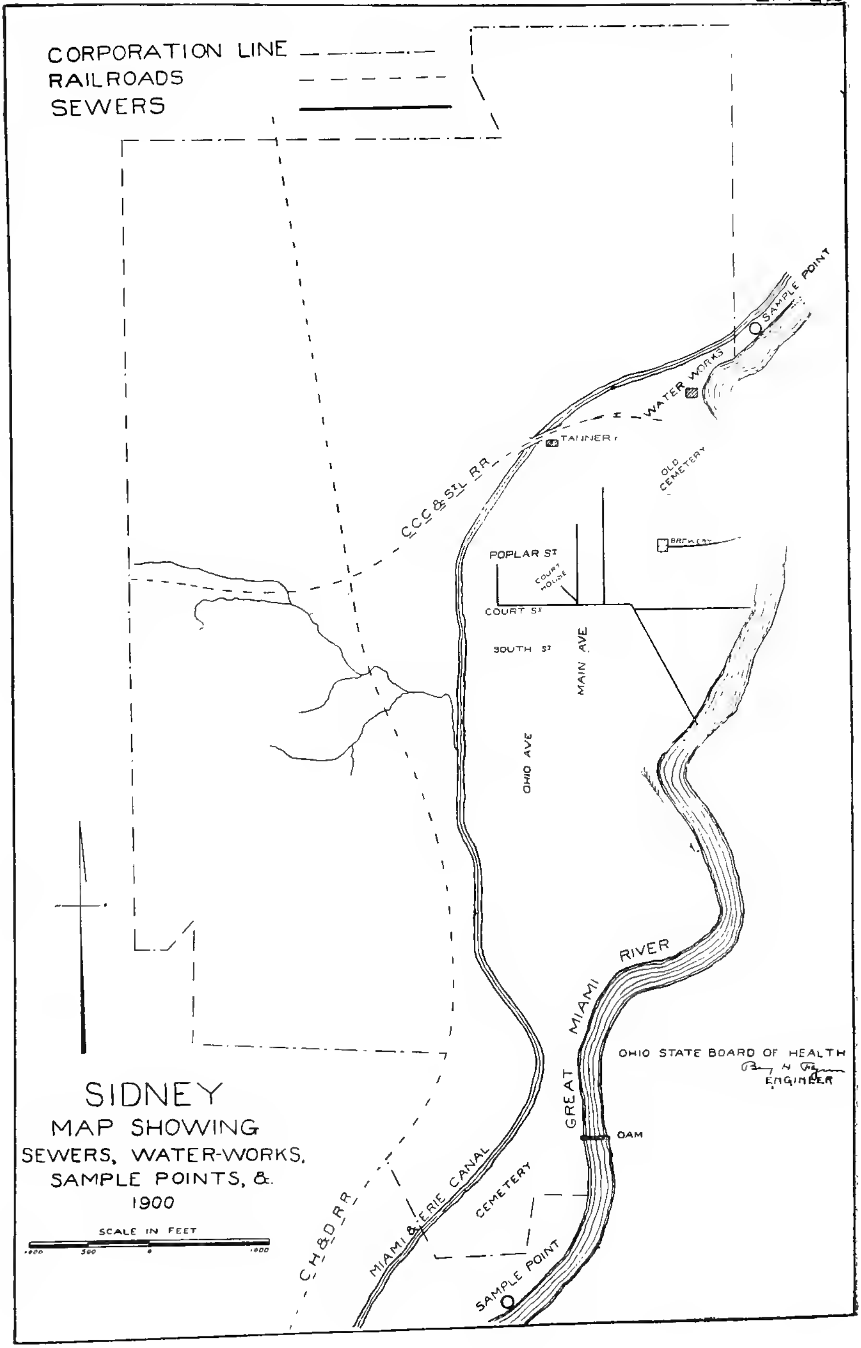

CORPORATION LINE
RAILROADS
SEWERS
SAMPLE POINT
WATER WORKS
TANNERY
C.C.C.&St.L. RR
OLD CEMETERY
BREWERY
POPLAR ST
COURT HOUSE
COURT ST
SOUTH ST
MAIN AVE
OHIO AVE
GREAT MIAMI RIVER
OHIO STATE BOARD OF HEALTH
ENGINEER
DAM
CEMETERY
SAMPLE POINT
MIAMI & ERIE CANAL
C.H.&D.RR
SIDNEY
MAP SHOWING
SEWERS, WATER-WORKS,
SAMPLE POINTS, &.
1900
SCALE IN FEET
1000
500
0
1000

PLATE 3

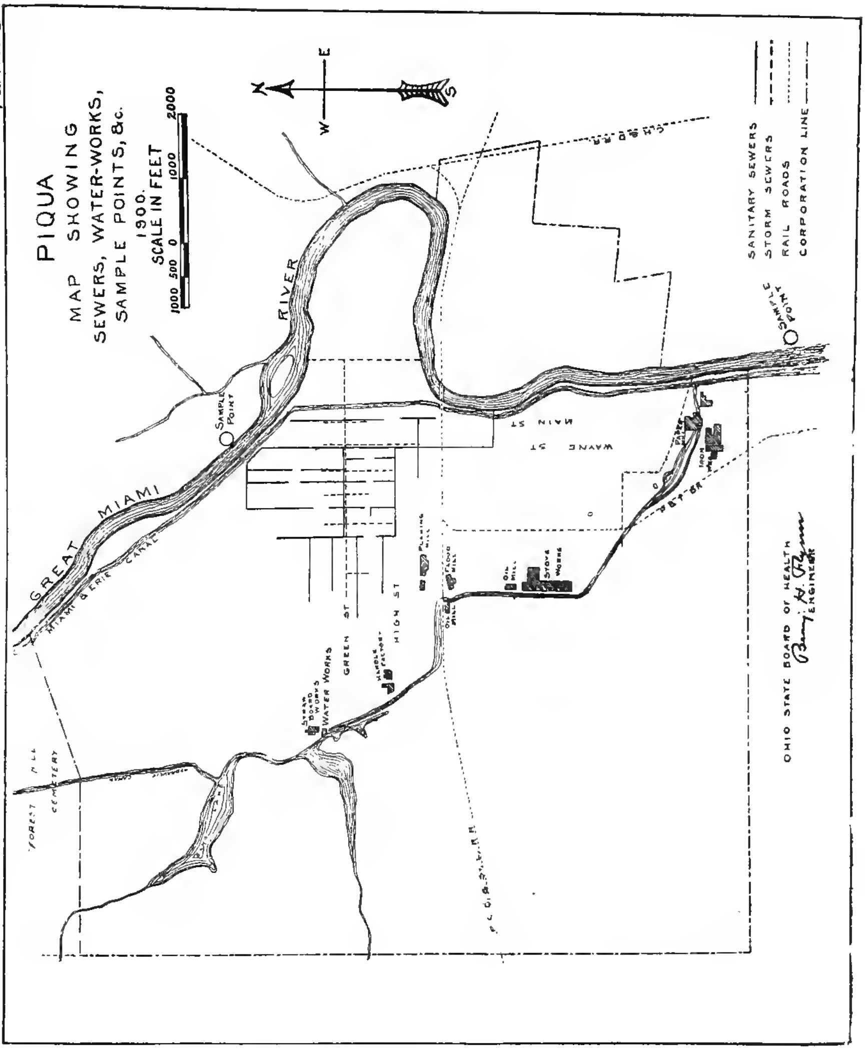

PIQUA
MAP SHOWING
SEWERS, WATER-WORKS,
SAMPLE POINTS, &c.
1900.
SCALE IN FEET
1000 500 0 1000 2000
N
S
E
W
GREAT MIAMI RIVER
MIAMI & ERIE CANAL
SAMPLE POINT
SAMPLE POINT
MAIN ST
WAYNE ST
GREEN ST
HIGH ST
WATER WORKS
STRAW BOARD WORKS
HANDLE FACTORY
PLANING MILL
FLOUR MILL
OIL MILL
OIL MILL
STOVE WORKS
PAPER MILL
IRON MILL
C H & D R.R.
P C C & St L R.R.
FOREST HILL CEMETERY
SANITARY SEWERS
STORM SEWERS
RAIL ROADS
CORPORATION LINE
OHIO STATE BOARD OF HEALTH
Benj. H. Flynn
ENGINEER

PLATE 4

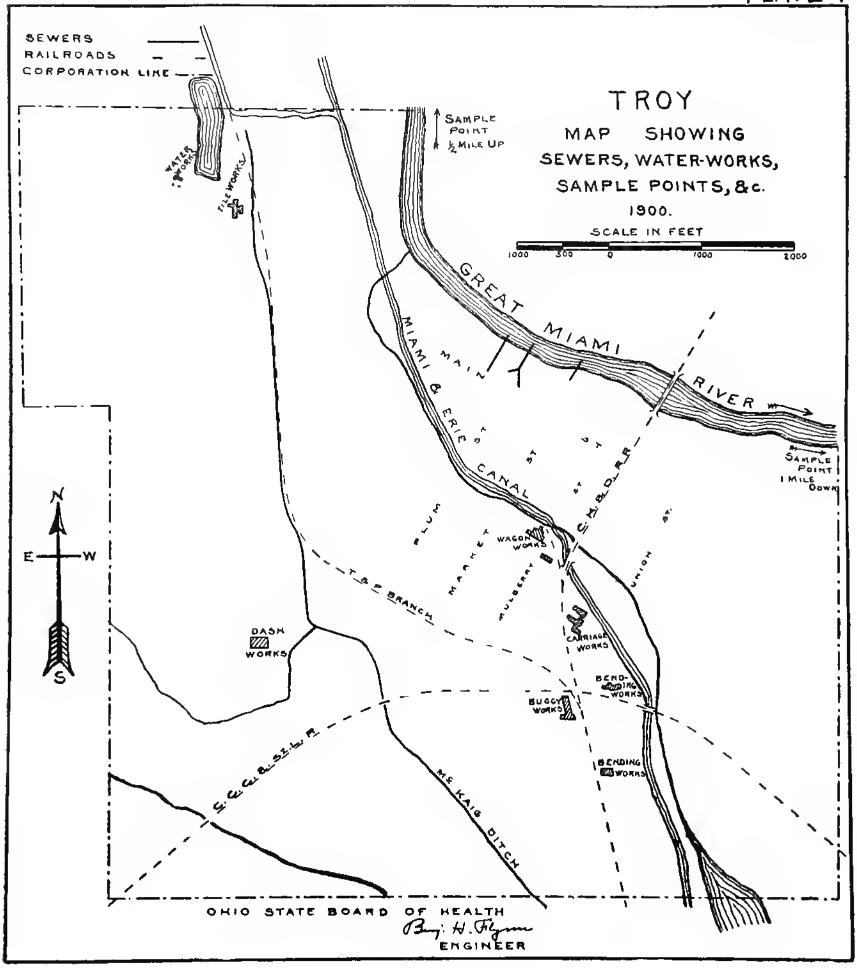

SEWERS
RAILROADS
CORPORATION LINE
TROY
MAP SHOWING
SEWERS, WATER-WORKS,
SAMPLE POINTS, &c.
1900.
SCALE IN FEET
1000 500 0 1000 2000
SAMPLE POINT ½ MILE UP
WATER WORKS
TILE WORKS
GREAT MIAMI RIVER
MAIN ST
MIAMI & ERIE CANAL
PLUM ST
MARKET ST
MULBERRY ST
UNION ST
C.H.&D.R.R.
WAGON WORKS
T.&P. BRANCH
DASH WORKS
CARRIAGE WORKS
BENDING WORKS
BUGGY WORKS
BENDING WORKS
C.C.C.&St.L.R.R.
McKAIG DITCH
SAMPLE POINT 1 MILE DOWN
N
E
W
S
OHIO STATE BOARD OF HEALTH
Benj. H. Flynn
ENGINEER

PLATE 5

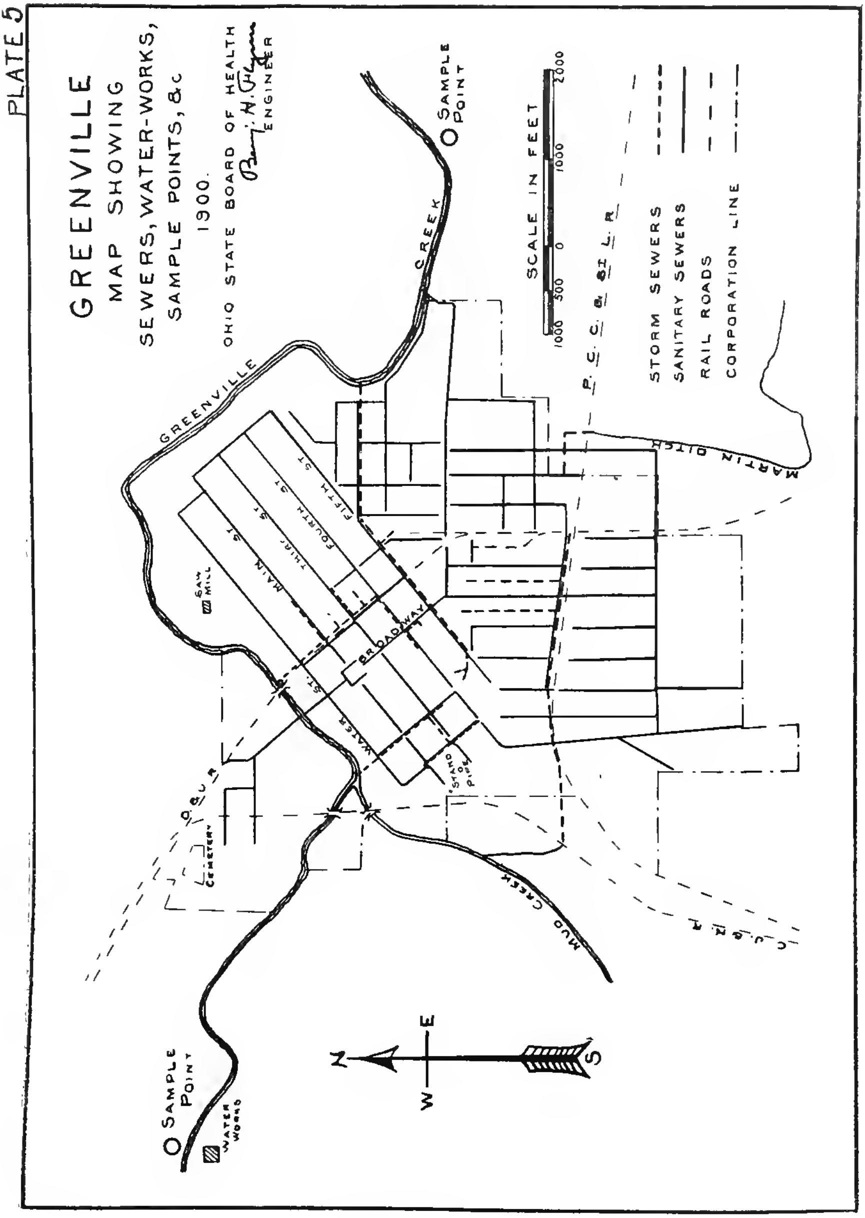

GREENVILLE
MAP SHOWING
SEWERS, WATER-WORKS,
SAMPLE POINTS, &c
1900.
OHIO STATE BOARD OF HEALTH
Benj. H. Flynn
ENGINEER
SAMPLE POINT
SCALE IN FEET
1000
500
0
1000
2000
STORM SEWERS
SANITARY SEWERS
RAIL ROADS
CORPORATION LINE
P. C. C. & St. L. R.
GREENVILLE CREEK
MARTIN DITCH
FIFTH ST
FOURTH ST
THIRD ST
MAIN ST
BROADWAY
WATER ST.
SAW MILL
STAND PIPE
CEMETERY
MUD CREEK
C. J. & M. R.
SAMPLE POINT
WATER WORKS
N
E
S
W

PLATE 6

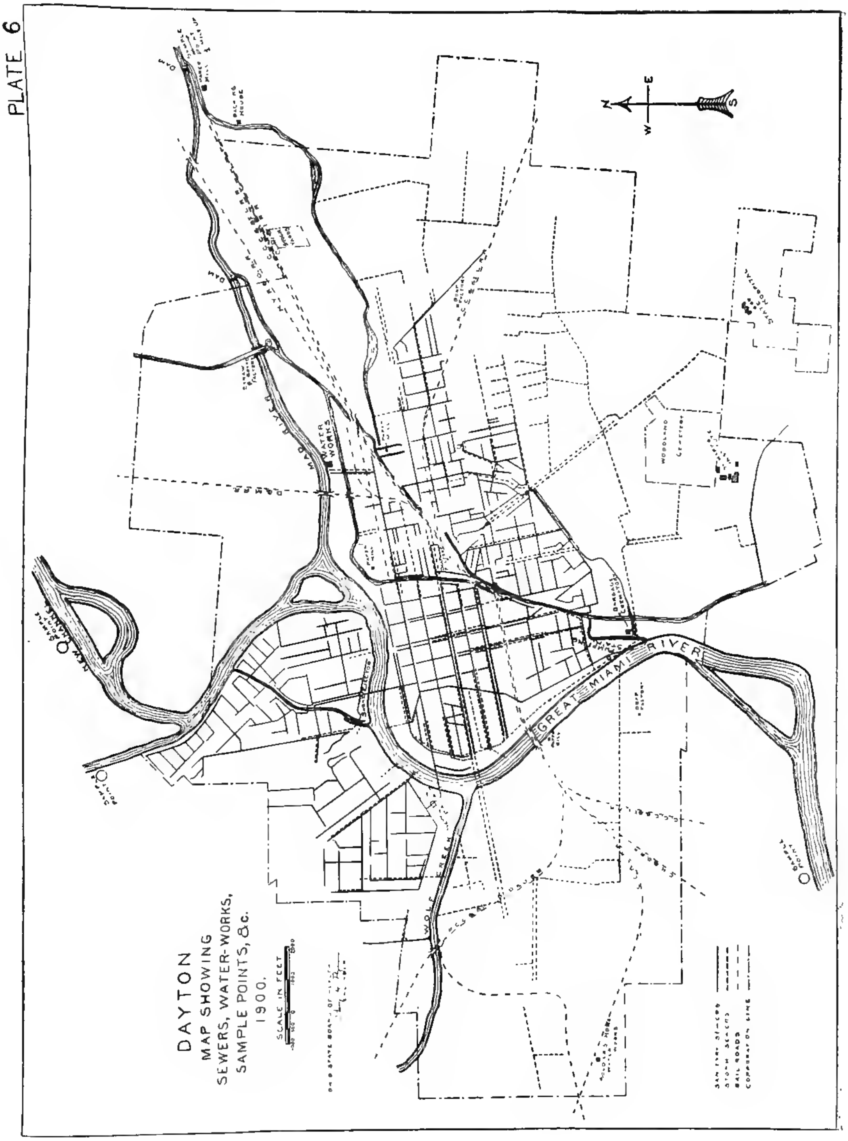

DAYTON
MAP SHOWING
SEWERS, WATER-WORKS,
SAMPLE POINTS, &c.
1900.
SCALE IN FEET
N
E
S
W
GREAT MIAMI RIVER
MAD RIVER
WOLF CREEK
WATER WORKS
DAM
WOODLAND CEMETERY
SAN. SEWERS
STORM SEWERS
RAILROADS
CORPORATION LINE

PLATE 7

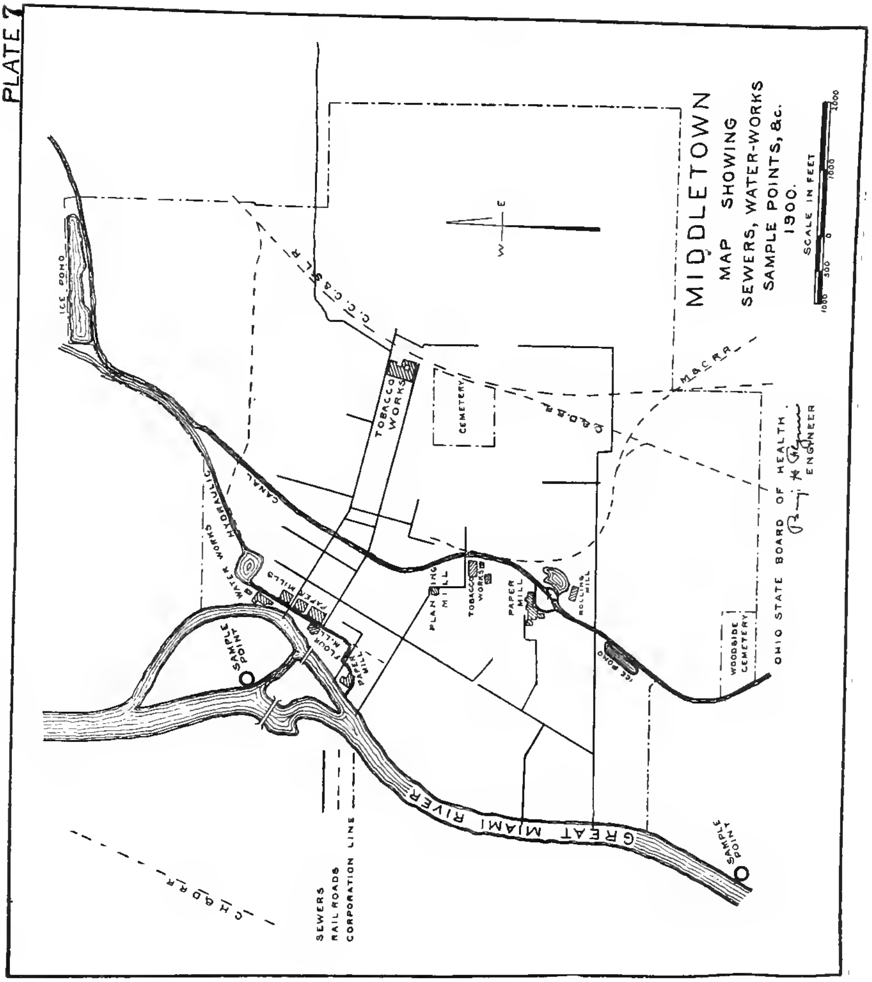

MIDDLETOWN
MAP SHOWING
SEWERS, WATER-WORKS
SAMPLE POINTS, &c.
1900.
SCALE IN FEET
1000
500
0
1000
2000
W
E
OHIO STATE BOARD OF HEALTH
Benj. H. Flynn
ENGINEER
SEWERS
RAIL ROADS
CORPORATION LINE
GREAT MIAMI RIVER
SAMPLE POINT
SAMPLE POINT
ICE POND
ICE POND
CANAL
HYDRAULIC
WATER WORKS
PAPER MILLS
FLOUR MILL
PAPER MILL
TOBACCO WORKS
TOBACCO WORKS
PLANING MILL
PAPER MILL
ROLLING MILL
CEMETERY
WOODSIDE CEMETERY
C.C.C.&.St.L.R.
M.&C.R.R.
C.&.D.R.R.
C.H.&.D.R.R.

PLATE 8

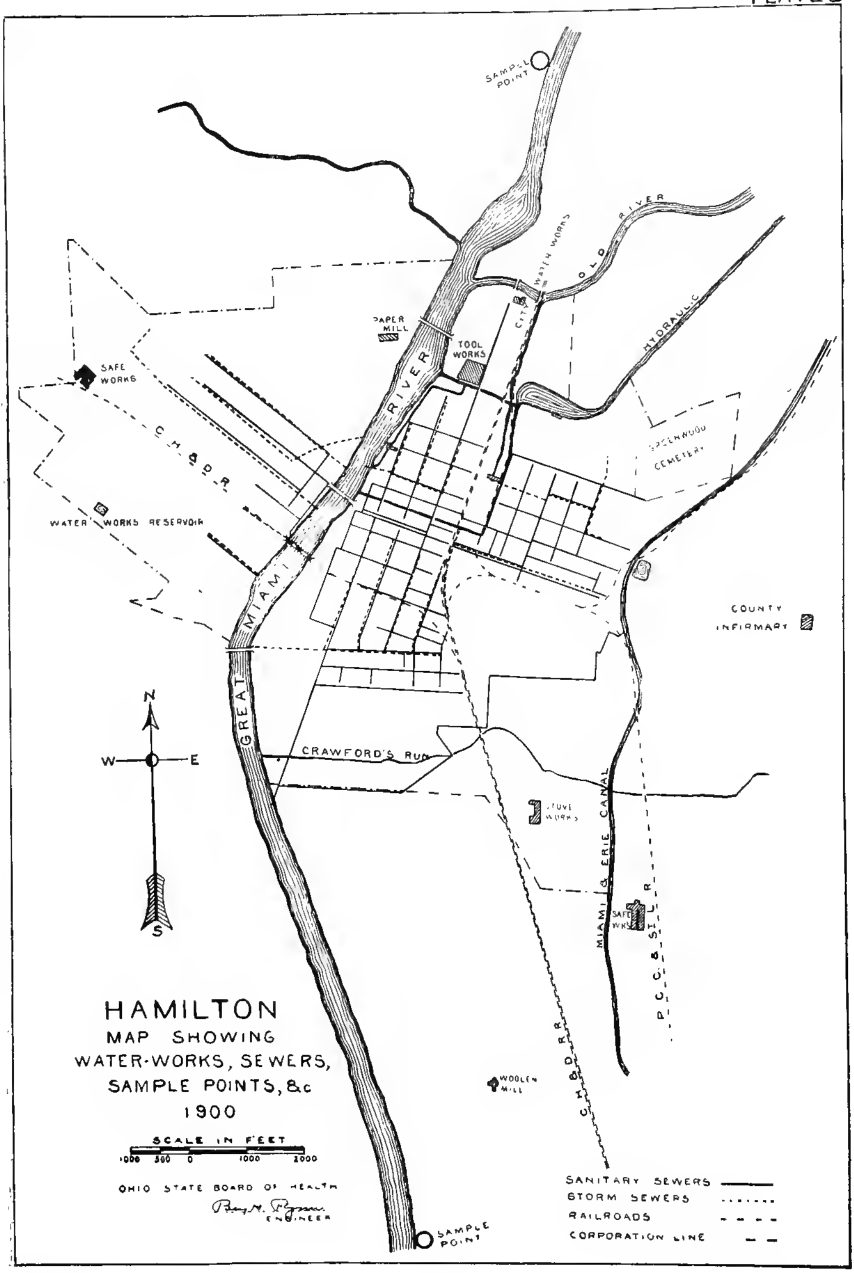

SAMPLE POINT
OLD RIVER
CITY WATER WORKS
HYDRAULIC
PAPER MILL
TOOL WORKS
SAFE WORKS
C. H. & D. R.
WATER WORKS RESERVOIR
GREAT MIAMI RIVER
GREENWOOD CEMETERY
COUNTY INFIRMARY
CRAWFORD'S RUN
STOVE WORKS
MIAMI & ERIE CANAL
SAFE WKS
P. C. C. & ST. L. R.
C. H. & D. R. R.
WOOLEN MILL
N
W
E
S
HAMILTON
MAP SHOWING
WATER-WORKS, SEWERS,
SAMPLE POINTS, &c
1900
SCALE IN FEET
1000 500 0 1000 2000
OHIO STATE BOARD OF HEALTH
ENGINEER
SANITARY SEWERS
STORM SEWERS
RAILROADS
CORPORATION LINE
SAMPLE POINT

PLATE 9

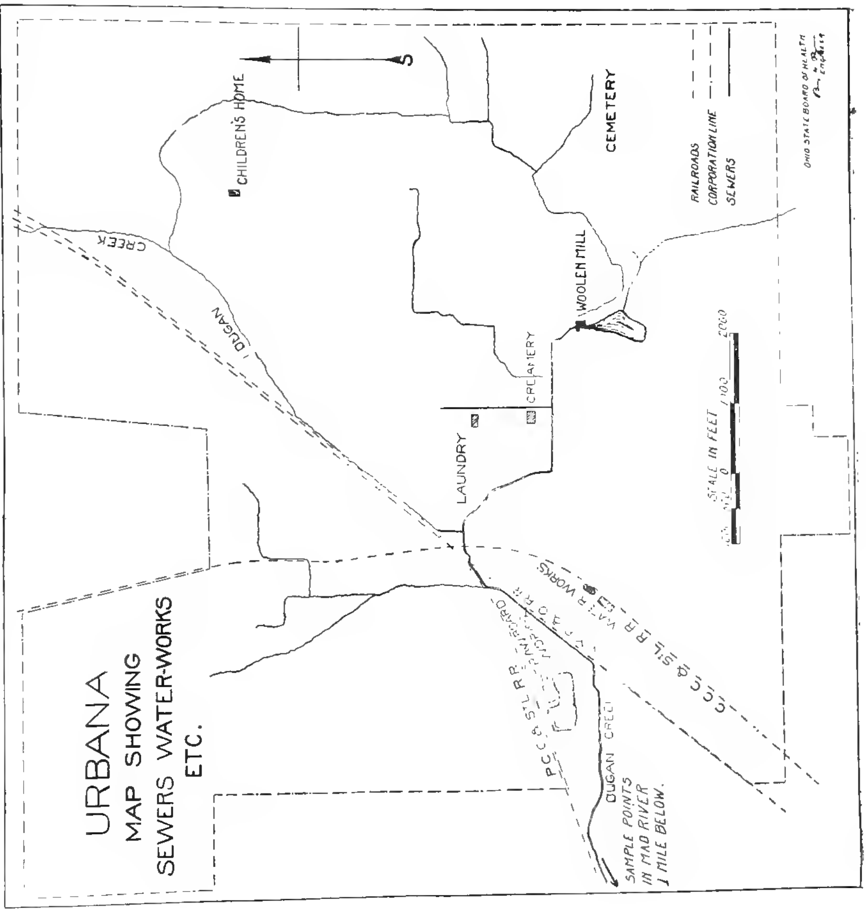
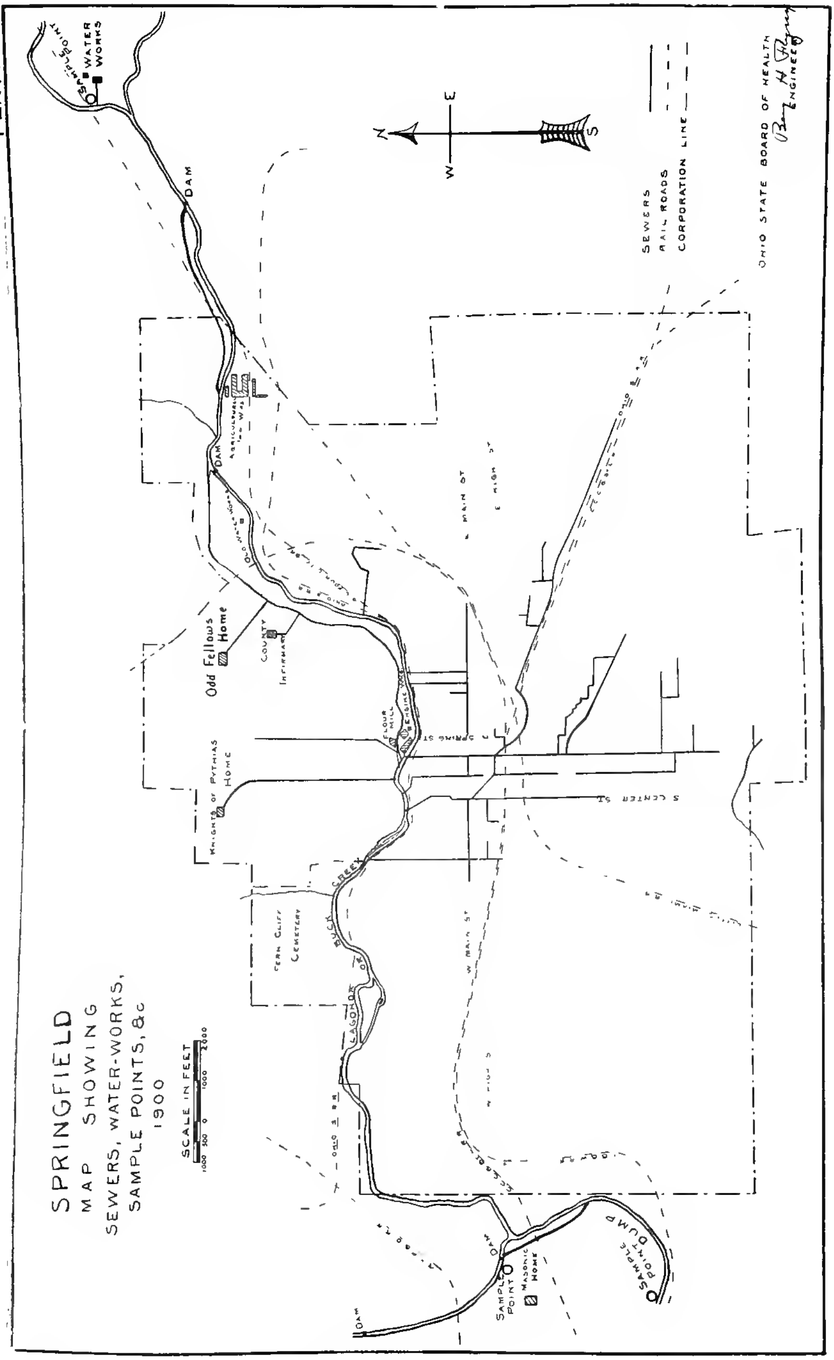

URBANA
MAP SHOWING
SEWERS WATER-WORKS
ETC.
S
CHILDREN'S HOME
CEMETERY
DUGAN CREEK
WOOLEN MILL
CREAMERY
LAUNDRY
WATER WORKS
C C C & St L R R
P C C & St L R R
DUGAN CREEK
SAMPLE POINTS
IN MAD RIVER
1 MILE BELOW.
RAILROADS
CORPORATION LINE
SEWERS
SCALE IN FEET
0
1000
2000
OHIO STATE BOARD OF HEALTH

PLATE 10



SPRINGFIELD
MAP SHOWING
SEWERS, WATER-WORKS,
SAMPLE POINTS, &c
1900

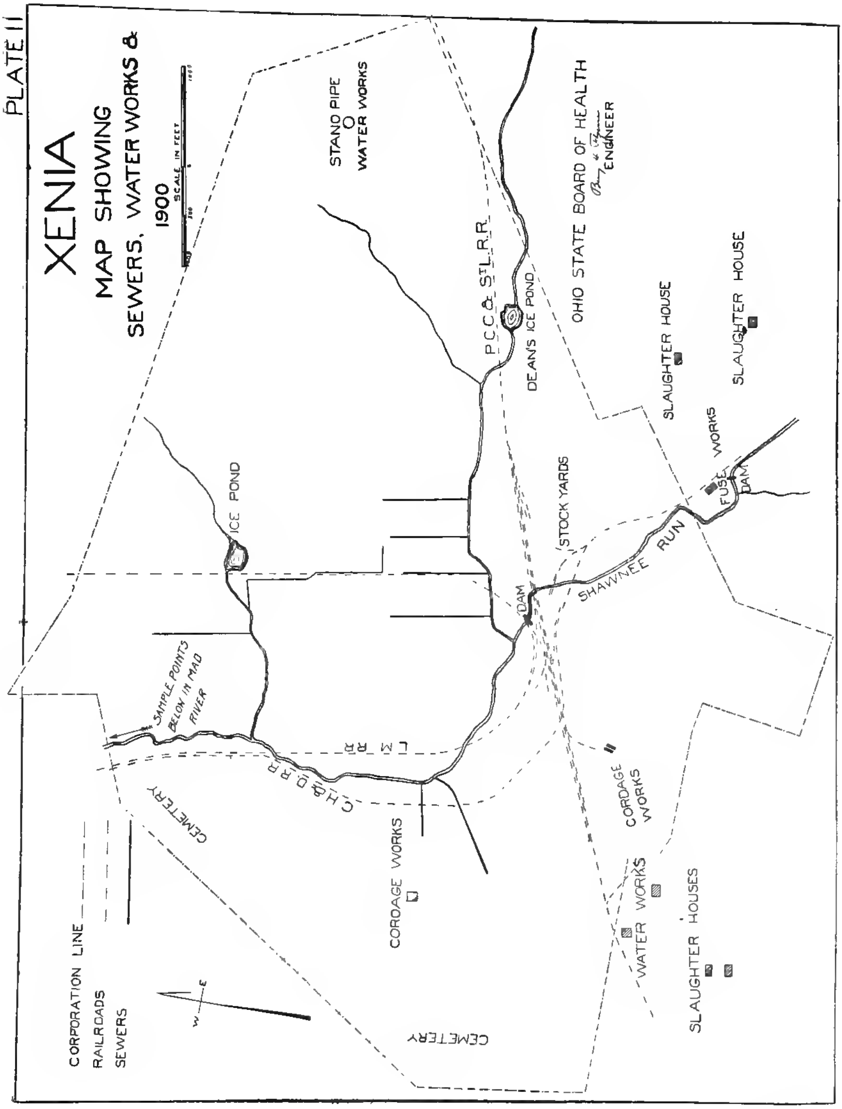
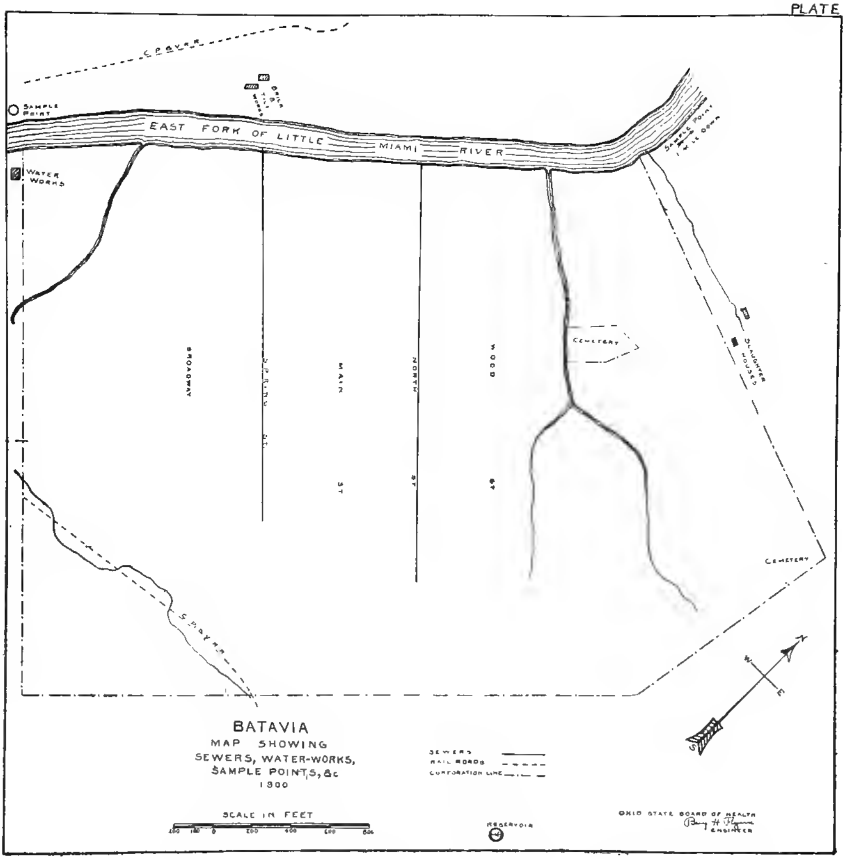


PLATE II
XENIA
MAP SHOWING
SEWERS, WATER WORKS &
1900
SCALE IN FEET
STAND PIPE
WATER WORKS
OHIO STATE BOARD OF HEALTH
ENGINEER
P.C.C.& St. L. R.R.
DEAN'S ICE POND
SLAUGHTER HOUSE
SLAUGHTER HOUSE
FUSE WORKS
DAM
STOCK YARDS
SHAWNEE RUN
DAM
ICE POND
SAMPLE POINTS BELOW IN MAD RIVER
L M RR
C H & D R R
CEMETERY
CORDAGE WORKS
CORDAGE WORKS
WATER WORKS
SLAUGHTER HOUSES
CEMETERY
CORPORATION LINE
RAILROADS
SEWERS
E
W

PLATE 12



BATAVIA
MAP SHOWING
SEWERS, WATER-WORKS,
SAMPLE POINTS, &c
1900

REPORT OF THE CHEMICAL AND BACTERIOLOGICAL EXAMINATIONS OF THE WATERS OF THE LITTLE MIAMI RIVER AND THE GREAT MIAMI RIVER WITH THEIR TRIBUTARIES.

By E. G. Horton, B. S.,

CHEMIST AND BACTERIOLOGIST TO THE OHIO STATE BOARD OF HEALTH.

SYNOPSIS.

I. INTRODUCTION.

II. METHODS OF EXAMINATION.

III. LIST OF SAMPLING STATIONS,
  1. LITTLE MIAMI RIVER,
  2. GREAT MIAMI WATERSHED.
    a. STILLWATER RIVER,
    b. MAD RIVER,
    c. GREAT MIAMI RIVER.

IV. LIST OF SAMPLES.

V. RAINFALL,
  1. RAINFALL TABLE,
  2. WEATHER HISTORY OF SAMPLES.
    a. LITTLE MIAMI RIVER,
    b. GREAT MIAMI RIVER.

VI. RESULTS OF EXAMINATIONS.

VII. LIST OF PLATES.

VIII. DISCUSSION OF ANALYTICAL RESULTS.
  1. LITTLE MIAMI RIVER,
  2. GREAT MIAMI WATERSHED.
    a. STILLWATER RIVER,
    b. MAD RIVER,
    c. GREAT MIAMI RIVER.

I. INTRODUCTION.

The rivers selected for the 1900 investigation were the two Miamis. The work on the Little Miami included the East Fork of that stream, while the tributaries of the Great Miami that were examined are those known as Greenville Creek, Buck Creek, Mad River, and Stillwater River. The relation of the tributaries to the main stream in each case is shown by diagram later. As in previous investigations the plan of work consisted in the examination of chemical and bacteriological samples taken monthly from chosen places or sampling stations. The work extended from April to November inclusive, and in the eight months fifty-four samples were taken from the seven stations on Little Miami River, and one hundred and seventy-six samples from the twenty-two stations on the Great Miami River, making a total of two hundred and thirty samples from twenty-nine sampling points. The April and September collections at South Charleston were not made.

With the amount of routine work on hand it was impossible to determine the absence or presence of intestinal bacteria in all the samples without an increased laboratory force, which was prevented by lack of funds. Some work was done along the line of searching for intestinal bacteria and the results will be found recorded later.

II. METHODS OF EXAMINATION.

The methods followed were the same as those of last year and reference is made to page 470 of the report of the Ohio State Board of Health for 1899, or to page 22 of the Third Report of an Investigation of the Rivers of Ohio.

In looking for intestinal bacteria it was our practice to employ preliminary cultivation over night in 1 per cent. peptone solution (using 10 cc. of 10 times normal peptone and 90 cc. of the water in question) then inoculation was made in 2 per cent. glucose bouillon in fermentation tubes, and on the production of gas, lactose-litmus-agar plates were poured and colonies picked for sub-culture work to identify the forms thus obtained.

III. LIST OF STATIONS.

The following list of sampling stations gives the location of the points where samples were collected, how the samples were taken, and the body of water from which they were taken. As in the preceding work the places selected were near the cities or large towns situated on the stream and just above and below the local pollutions. The expression "from the bank" means from the bank when the current swept up to the bank in such a manner as to give a representative sample, otherwise the collector waded out a few steps from the bank to make the collection.

1. LITTLE MIAMI RIVER.

1. Above South Charleston. The collections were made from a log or from the bank in a little pool just as the stream entered the lot of James Duffey, on the London pike, some three-fourths ot a mile from the village.

2 and 3. Above and below Xenia. Both sets of samples were taken from a naptha launch (or row boat), at Lucas Grove. The upper samples were taken nearly a mile above the mouth of Shawnee Run, and the lower ones just above the dam at the Trebein mill.

4. Above Loveland at a point where the river bends to the highway and Panhandle railroad about a mile above the village. The samples were taken by wading from the east bank.

5. Opposite Linwood where Union levee crosses the river. The samples were taken by wading from the west bank just south of the bridge.

EAST FORK OF LITTLE MIAMI RIVER.

6. Above Batavia. The samples were taken from a boat in the pool opposite the water works. As the intake pipe of the city water works is in this pool the examinations at this station show the character of the water (before filtration) used by Batavia.

7. Below Batavia. The collections were made from the right bank of the stream about half a mile below the outlet of the Clermont County Infirmary's sewer.

2. GREAT MIAMI WATERSHED.

a. STILLWATER BASIN.

8. Above Greenville. The above town samples were taken from the roots of a tree on the right bank, or from a boat, and represented the water in Greenville Creek just above the old intake.

9. Below Greenville. These samples were taken from Greenville Creek by wading at the foot of Martin Street. During the later months the collections were made about half a mile farther down the stream, as the village of Greenville was being sewered and the outlet was at the foot of Martin Street.

10. Above Dayton on Stillwater River. The samples were here collected from a row-boat at the Y. M. C. A. Athletic grounds.

b. MAD RIVER BASIN.

11. Above Urbana. This station was located on Mad River just above the bridge on the Urbana and Westville or Piqua Pike. The collections were made from the bank.

12. Below Urbana. This station on Mad River was a little less than a mile below the mouth of Dugan Creek and was situated a few rods above the Redmond highway bridge crossing the stream at this place. Wading was necessary to obtain representative samples.

13. Above Springfield on Buck Creek. The only station located on Buck Creek was near the Springfield water works pumping station, and at the point where the intake pipe reaches the creek. The first samples were taken from the rocks on the left bank, but the later ones were collected from the planks placed about the mouth of the intake pipe.

14. Above Springfield on Mad River. Samples were taken by wading into the river a short distance below the West Main Street (National road) bridge.

15. Below Springfield on Mad River. The April collection was made just above the old White bridge near John Wood's factory, but later ones were made farther down, where the river bends to the railroad track. At the latter place the collections were made from a projecting rock on the left bank.

16. Above Dayton on Mad River. The samples were taken by wading a few rods above the bridge west of Harshmanville.

c. GREAT MIAMI RIVER BASIN.

(Under this heading is included only the main stream.)

17. Above Sidney. The collections were made from the Great Miami where it is obstructed by the stone dam opposite the water works pumping station.

18. Below Sidney. This station was located on the Great Miami just above Sulphur Spring or White bridge, and the collections were made by wading.

19. Above Piqua. The samples were taken from the right bank just above the Main Street bridge.

20. Below Piqua. This station was established on the left bank of the Great Miami and in front of Henry Dorman's house.

21. Above Troy. The April and May samples were taken from the left bank above the outlet of the sewer from the Miami County Infirmary, but later collections were made from the opposite bank because that point was easier of access.

22. Below Troy. The samples at this place were taken from a boat or by wading at a point on the Edwards farm opposite "Horse Heaven" and a few rods above the Big Four railroad bridge.

23. Above Dayton on the Great Miami River. For seven months this station was just above the Troy pike bridge over the old channel, and the collections were made from the rocks on the left bank. The November sample was taken in the new channel a few rods below the bridge, as the water had been turned into the new channel about two weeks previous to the November sampling.

24. Below Dayton on the Great Miami River. The samples were taken from a row boat off the right bank at the foot of Broadway Street.

25. Above Middletown. The samples at this station were secured by wading from the east shore a few rods above "Second River" bridge.

26. Below Middletown. This station was located at the swimming hole on the Hale farm. The collections were made from a boat.

27. Above Hamilton. The collections were made on the right bank from the ruins of the old dam opposite station No. 159 on the electric railway between Hamilton and Middletown.

28. Below Hamilton. This station was situated at the camping ground on the Richard Brown farm and the samples were obtained by wading. The April sample was collected from the opposite side of the river.

29. Below Cleves. The April sample was taken below the mouth of Whitewater River, but the latter collections were made from the left bank of the Great Miami about a quarter of a mile below Harold switch on the Cincinnati and Lawrenceburg electric line, and consequently some distance above the mouth of Whitewater River. This change in position of the station was due to the fact that most of the territory drained by the tributary mentioned lies outside of the state of Ohio.

For a better idea of the general distribution of the stations and of their relation to the various tributaries and the main stream, the reader is referred to the diagrammatic representation of the systems of the Little and Great Miami Rivers given on page 91. The relative location of each station to its adjacent city or village is best shown on the individual map for the city or village. See pages 6-16.

IV. LIST OF SAMPLES.

IN THE FOLLOWING LIST THE SAMPLES ARE GIVEN BY SERIAL NUMBER, WHERE AND WHEN TAKEN, AND THE TIME THEY WERE RECEIVED AT THE LABORATORY.

1. Springfield, above, Buck Creek, April 16, 2:50 P. M. Received April 17, 9:45 A. M.

2. Springfield, above, Mad River, April 16, 3:55 P. M. Received April 17, 9:45 A. M.

3. Springfield, below, Mad River, April 16, 4.30 P. M. Received April 17, 9:45 A. M.

4. Troy, above, Great Miami River, April 17, 8:00 A. M. Received April 18, 11:30 A. M.

5. Troy, below, Great Miami River, April 17, 9:00 A. M. Received April 18, 11:30 A. M.

6. Sidney, below, Great Miami River, April 17, 12:20 P. M. Received April 18, 11:30 A. M.

7. Sidney, above, Great Miami River, April 17, 12:50 P. M. Received April 18, 11:30 A. M.

8. Greenville, above, Greenville Creek, April 17, 4:15 P. M. Received April 19, 1:15 P. M.

9. Greenville, below, Greenville Creek, April 17, 5:00 P. M. Received April 19, 1:15 P. M.

10. Dayton, below, Great Miami River, April 18, 9:20 A. M. Received April 19, 1:15 P. M.

11. Dayton, above, Mad River, April 18, 10:40 A. M. Received April 21, 10:30 A. M.

12. Dayton, above, Great Miami River, April 18, 11:50 A. M. Received April 19, 1:15 P. M.

13. Dayton, above, Stillwater River, April 18, 12:15 P. M. Received April 19, 1:15 P. M.

14. Piqua, above, Great Miami River, April 18, 4:00 P. M. Received April 19, 1:15 P. M.

15. Piqua, below, Great Miami River, April 18, 4:40 P. M. Received April 19, 1:15 P. M.

16. Urbana, above, Made River, April 19, 10:45 A. M. Received April 20, 8:00 A. M.

17. Urbana, .below, Mad River, April 19, 12:00 M. Received April 20, 8:00 A. M.

18. Loveland, above, Little Miami River, April 24, 10:30 A. M. Received April 25, 9:30 A. M.

19. Linwood, below, Little Miami River, April 24, 3:00 P. M. Received April 25, 4:15 P. M.

20. Batavia, above, East Fork of Little Miami River, April 25, 7:45 A. M. Received April 26, 9:00 A. M.

21. Batavia, below, East Fork of Little Miami River, April 25, 8:00 A. M. Received April 26, 9:00 A. M.

22. Cleves, below, Great Miami River, April 25, 12:00 M. Received April 26, 11:15 A. M.

23. Hamilton, below, Great Miami River, April 25, 5:15 P. M. Received April 27, 8:00 A. M.

24. Hamilton, above, Great Miami River, April 25, 6:00 P. M. Received April 27, 8:00 A. M.

25. Middletown, below, Great Miami River, April 26, 8:30 A. M. Received April 27, 10:00 A. M.

26. Middletown, above, Great Miami River, April 26, 9:15 A. M. Received April 27, 10:00 A. M.

27. Xenia, above, Little Miami River, April 26, 3:00 P. M. Received April 27, 8:00 A. M.

28. Xenia, below, Little Miami River, April 26, 3:20 P. M. Received April 27, 8:00 A. M.

29. Piqua, above, Great Miami River, May 22, 9:45 A. M. Received May 23, 2:00 P. M.

30. Piqua, below, Great Miami River, May 22, 10:15 A. M. Received May 23, 2:00 P. M.

31. Sidney, below, Great Miami River, May 22, 12:30 P. M. Received May 24, 9:45 A. M.

32. Sidney, above, Great Miami River, May 22, 1:15 P. M. Received May 24, 9:45 A. M.

33. Greenville, above, Greenville Creek, May 22, 1:15 P. M. Received May 24, 9:45 A. M.

34. Greenville, below, Greenville Creek, May 22, 5:30 P. M. Received May 24, 9:45 A. M.

35. Dayton, below, Great Miami River, May 23, 8:00 A. M. Received May 25, 8:00 A. M.

36. Dayton, above, Mad River, May 23, 9:05 A. M. Received May 25, 8:00 A. M.

37. Dayton, above, Great Miami River, May 23, 10:00 A. M. Received May 25, 8:00 A. M.

38. Dayton, above, Stillwater River, May 23, 10:25 A. M. Received May 25, 8:00 A. M.

39. Troy, below, Great Miami River, May 22, 3:40 P. M. Received May 24, 2:00 P. M.

40. Troy, above, Great Miami River, May 22, 4:25 P. M. Received May 24, 2:00 P. M.

41. Urbana, above, Mad River, May 24, 7:30 A. M. Received May 25, 9:30 A. M.

42. Urbana below, Mad River, May 24, 8:30 A. M. Received May 25, 9:30 A. M.

43. Springfield, below, Mad River, May 24, 11:30 A. M. Received May 25, 10:30 A. M.

44. Springfield, above, Mad River, May 24, 12:00 M. Received May 25, 10:30 A. M.

45. Springfield, above, Buck Creek, May 24, 2:20 P.M. Received May 25, 10:30 A. M.

46. South Charleston, above, Little Miami River, May 28, 8:30 A. M. Received May 29, 11:00 A. M.

47. Xenia, above, Little Miami River, May 28, 11:30 A. M. Received May 29, 8:30 A. M.

48. Xenia, below, Little Miami River, May 28, 12:00 M. Received May 29, 8:30 A. M.

49. Middletown, above, Great Miami River, May 28, 3:45 P. M. Received May 30, 8:00 A. M.

50. Middletown, below, Great Miami River, May 28, 4:15 P. M. Received May 30, 8:00 A. M.

51. Hamilton, above Great Miami River, May 28, 5:30 P. M. Received May 30, 9:00 A. M.

52. Hamilton, below, Great Miami River, May 28, 6:15 P. M. Received May 30, 9:00 A. M.

53. Cleves, below, Great Miami River, May 29, 8:00 A. M. Received May 30, 11:00 A. M.

54. Linwood, below, Little Miami River, May 29, 12:45 P. M. Received May 30, 9:30 A. M.

55. Loveland, above, Little Miami River, May 29, 3:30 P. M. Received May 30, 8:00 A. M.

56. Batavia, below, East Fork of Little Miami River, June 1, 2:30 P. M. Received June 2, 9:00 A. M.

57. Batavia, above, East Fork of Little Miami River, June 1, 3:00 P. M. Received June 2, 9:00 A. M.

58. Piqua, above, Great Miami River, June 18, 9:45 A. M. Received June 19, 8:00 A. M.

59. Piqua, below, Great Miami River, June 18, 10:15 A. M. Received June 19, 8:00 A. M.

60. Sidney, below, Great Miami River, June 18, 12:30 P. M. Received June 20, 10:00 A. M.

61. Sidney, above, Great Miami River, June 18, 1:15 P. M. Received June 20, 10:00 A. M.

62. Greenville, above, Greenville Creek, June 18, 4:00 P. M. Received June 20, 10:00 A. M.

63. Greenville, below, Greenville Creek, June 18, 4:30 P. M. Received June 20, 10:00 A. M.

64. Dayton, below, Great Miami River, June 19, 7:30 A. M. Received June 20, 8:30 A. M.

65. Dayton, above, Mad River, June 19, 9:30 A. M. Received June 20, 8:30 A. M.

66. Dayton, above, Great Miami River, June 19, 10:30 A. M. Received June 20, 8:30 A. M.

67. Dayton, above, Stillwater River, June 19, 11:00 A. M. Received June 20, 8:30 A. M.

68. Troy, below, Great Miami River, June 19, 3:30 P. M. Received June 21, 8:00 A. M.

69. Troy, above, Great Miami River, June 19, 4:45 P. M. Received June 21, 8:00 A. M.

70. Urbana, below, Mad River, June 20, 8:15 A. M. Received June 20, 8:00 P. M.

71. Urbana, above, Mad River, June 20, 9:15 A. M. Received June 20, 8:00 P. M.

72. Springfield, above, Buck Creek, June 20, 1:30 P. M. Received June 21, 10:00 A. M.

73. Springfield, above, Mad River, June 20, 2:45 P. M. Received June 21, 10:00 A. M.

74. Springfield, below, Mad River, June 20, 3:30 P. M. Received June 21, 10:00 A. M.

75. South Charleston, above, Little Miami River, June 26, 8:30 A. M. Received June 27, 8:20 A. M.

76. Loveland, above, Little Miami River, June 26, 1:35 P. M. Received June 27, 8:20 A. M.

77. Linwood, below, Little Miami River, June 26, 5:00 P. M. Received June 28, 8:30 A. M.

78. Batavia, above, East Fork of Little Miami River, June 27, 7:15 A. M. Received June 28, 8:30 A. M.

79. Batavia, below, East Fork of Little Miami River, June 27, 8:00 A. M. Received June 28, 8:30 A. M.

80. Cleves, below, Great Miami River, June 27, 11:30 A. M. Received June 28, 10:00 A. M.

81. Hamilton, above, Great Miami River, June 27, 6:00 P. M. Received June 30, 8:40 A. M.

82. Hamilton, below, Great Miami River, June 27, 7:00 P. M. Received June 30, 8:40 A. M.

83. Middletown, above, Great Miami River, June 28, 7:30 A. M. Received June 29, 10:00 A. M.

84. Middletown, below, Great Miami River, June 28, 8:00 A. M. Received June 29, 10:00 A. M.

85. Xenia, above, Little Miami River, June 28, 11:30 A. M. Received June 29, 8:25 A. M.

86. Xenia, below, Little Miami River, June 28, 12:00 M. Received June 29, 8:25 A. M.

87. Urbana, below Mad River, July 9, 9:30 A. M. Receeived July 10, 8:15 A. M.

88. Urbana, above Mad River, July 9, 10:15 A. M. Received July 10, 8:15 A. M.

89. Sidney, below, Great Miami River, July 9, 2:30 P. M. Received July 11, 9:45 A. M.

90. Sidney, above, Great Miami River, July 9, 3:30 P. M. Received July 11, 9:45 A. M.

91. Greenville, above, Greenville Creek, July 10, 6:00 A. M. Received July 11, 9:45 A. M.

92. Greenville, below Greenville Creek, July 10, 6:45 A. M. Received July 11, 9:45 A. M.

93. Dayton, above Mad River, July 10, 11:00 A. M. Received July 11, 9:45 A. M.

94. Dayton, above Great Miami River, July 10, 12:00 M. Received July 11, 9:45 A. M.

95. Dayton, above, Stillwater River, July 10, 12:45 P. M. Received July 11, 9:45 A. M.

96. Dayton, below, Great Miami River, July 10, 1:30 P. M. Received July 11, 9:45 A. M.

97. Springfield, above, Mad River, July 10, 4:00 P. M. Received July 11, 3:30 P. M.

98. Springfield, below, Mad River, July 10, 4:45 P. M. Received July 11, 3:30 P. M.

99. Springfield, above, Buck Creek, July 10, 6:30 P. M. Received July 11, 3:30 P. M.

100. Troy, below, Great Miami River, July 11, 8:45 A. M. Received July 12, 9:15 A. M.

101. Troy, above, Great Miami River, July 11, 9:45 A. M. Received July 12, 9:15 A. M.

102. Piqua, below, Great Miami River, July 11, 11.30 A. M. Received July 12, 8:30 A. M.

103. Piqua, above, Great Miami River, July 11, 12:00 M. Received July 12, 8:30 A. M.

104. Xenia, below, Little Miami River, July 17, 9:20 A. M. Received July 18, 8:15 A. M.

105. Xenia, above, Little Miami River, July 17, 9:40 A. M. Received July 18, 8:15 A. M.

106. Loveland, above, Little Miami River, July 17, 1:30 P. M. Received July 18, 8:00 A. M.

107. South Charleston, above, Little Miami River, July 17, 5:30 P. M. Received July 18, 8:00 A. M.

108. Middletown, above, Great Miami River, July 19, 10:00 A. M. Received July 20, 9:30 A. M.

109. Middletown, below, Great Miami River, July 19, 10:30 A. M. Received July 20, 9:30 A. M.

110. Hamilton, above, Great Miami River, July 19, 12:15 P. M. Received July 20, 9:00 A. M.

111. Hamilton, below, Great Miami River, July 19, 1:15 P. M. Received July 20, 9:00 A. M.

112. Linwood, below, Little Miami River, July 19, 4:30 P. M.. Received July 21, 9:00 A. M.

113. Batavia, below, East Fork of Little Miami River, July 20, 7:00 A. M. Received July 21, 9:00 A. M.

114. Batavia, above, East Fork of Little Miami River, July 20, 8:00 A. M. Received July 21, 9:00 A. M.

115. Cleves, below, Great Miami River, July 20, 11:25 A. M. Received July 21, 10:00 A. M.

116. Piqua, above, Great Miami River, Aug. 7, 9:45 A. M. Received August 8, 8:30 A. M.

117. Piqua, below, Great Miami River, Aug. 7, 10:15 A. M. Received Aug. 8, 8:30 A. M.

118. Sidney, below, Great Miami River, Aug. 7, 12:30 P. M. Received Aug. 9, 10:00 A. M.

119. Sidney, above, Great Miami River, Aug. 7, 1:15 P. M. Received Aug. 9, 10:00 A. M.

120. Greenville, above, Greenville Creek, Aug. 7, 4:30 P. M. Received Aug. 9, 10:00 A. M.

121. Greenville, below, Greenville Creek, Aug. 7, 5:30 P. M. Received Aug. 9, 10:00 A. M.

122. Dayton, below, Great Miami River, Aug. 8, 7:30 A. M. Received Aug. 9, 10:00 A. M.

123. Dayton, above, Mad River, Aug. 8, 9:30 A. M. Received Aug. 9, 10:00 A. M.

124. Dayton, above, Great Miami River, Aug. 8, 10:45 A. M. Received Aug. 9, 10:00 A. M.

125. Dayton, above, Stillwater River, Aug. 8, 11:20 A. M. Received Aug. 9, 10:00 A. M.

126. Troy, below, Great Miami River, Aug. 8, 4:00 P. M. Received Aug. 9, 2:00 P. M.

127. Troy, above, Great Miami River, Aug. 8, 5:15 P. M. Received Aug. 9, 2:00 P. M.

128. Urbana, above, Mad River, Aug. 9, 8:00 A. M. Received Aug. 10, 10:00 A. M.

129. Urbana, below, Mad River, Aug. 9, 8:45 A. M. Received Aug. 10, 10:00 A. M.

130. Springfield, below, Mad River, Aug. 9, 1:00 P. M. Received Aug. 10, 10:00 A. M.

131. Springfield, above, Mad River, Aug. 9, 1:45 P. M. Received Aug. 10, 10:00 A. M.

132. Springfield, above, Buck Creek, Aug. 9, 3:30 P. M. Received Aug. 10, 10:00 A. M.

133. South Charleston, above, Little Miami River, Aug. 20, 8:45 A. M. Received Aug. 20, 4:00 P. M.

134. Loveland, above, Little Miami River, Aug. 20, 1:00 P. M. Received Aug. 21, 10:00 A. M.

135. Linwood, below, Little Miami River, Aug. 20, 4:15 P. M. Received Aug. 22, 8:00 A. M.

136. Batavia, below, East Fork of Little Miami River, Aug. 21, 7:15 A. M. Received Aug. 22, 8:15 A. M.

137. Batavia, above, East Fork of Little Miami River, Aug. 21, 8:00 A. M. Received Aug. 22, 8:15 A. M.

138. Cleves, below, Great Miami River, Aug. 21, 12:15 P. M. Received Aug. 22, 8:15 A. M.

139. Hamilton, below, Great Miami River, Aug. 21, 4:30 P. M. Received Aug. 23, 8:45 A. M.

140. Hamilton, above, Great Miami River, Aug. 21, 5:30 P. M. Received Aug. 23, 8:45 A. M.

141. Middletown, above, Great Miami River, Aug. 22, 7:15 A. M. Received Aug. 23, 8:00 A. M.

142. Middletown, below, Great Miami River, Aug. 22, 8:00 A. M. Received Aug. 23, 8:00 A. M.

143. Xenia, above, Little Miami River, Aug. 22, 11:15 A. M. Received Aug. 23, 8:45 A. M.

144. Xenia, below, Little Miami River, Aug. 22, 11:45 A. M. Received Aug. 23, 8:45 A. M.

145. Piqua, above, Great Miami River, Sept. 3, 9:45 A. M. Received Sept. 4, 2:10 P. M.

146. Piqua, below, Great Miami River, Sept. 3, 10:15 A. M. Received Sept. 4, 2:10 P. M.

147. Sidney, below, Great Miami River, Sept. 3, 12:30 P. M. Received Sept. 5, 8:00 A. M.

148. Sidney, above, Great Miami River, Sept. 3, 1:15 P. M. Received Sept. 5, 8:00 A. M.

149. Greenville, above, Greenville Creek, Sept. 3, 4:30 P. M. Received Sept. 5, 8:00 A. M.

150. Greenville, below, Greenville Creek, Sept. 3, 5:00 P. M. Received Sept. 5, 8:00 A. M.

151. Dayton, above, Mad River, Sept. 4, 8:30 A. M. Received Sept. 5, 8:00 A. M.

152. Dayton, above, Great Miami River, Sept. 4, 9:45 A. M. Received Sept. 5, 8:00 A. M.

153. Dayton, above, Stillwater River, Sept. 4, 10:45 A. M. Received Sept. 5, 8:00 A. M.

154. Dayton, below, Great Miami River, Sept 4, 11:45 A. M. Received Sept. 5, 8:00 A. M.

155. Troy, below, Great Miami River, Sept. 4, 3:45 P M. Received Sept. 5, 8:00 A. M.

156. Troy, above, Great Miami River, Sept. 4, 4:45 P. M. Received Sept. 5, 8:00 A. M.

157. Urbana, below, Mad River, Sept. 5, 7:45 A. M. Received Sept. 6, 8:00 A. M.

158. Urbana, above, Mad River, Sept. 5, 8:30 A. M. Received Sept. 6, 8:00 A. M.

159. Springfield, above, Mad River, Sept. 5, 11:15 A. M. Received Sept. 6, 8:00 A. M.

160. Springfield, below, Mad River, Sept. 5, 12:00 M. Received Sept. 6, 8:00 A. M.

161. Springfield, above, Buck Creek, Sept. 5, 2:15 P. M. Received Sept. 6, 8:00 A. M.

162. Xenia, above, Little Miami River, Sept. 17, 11:30 A. M. Received Sept. 18, 10:00 A. M.

163. Xenia, below, Little Miami River, Sept. 17, 12:15 P M. Received Sept. 18, 10:00 A. M.

164. Loveland, above, Little Miami River, Sept. 17, 5:15 P. M. Received Sept. 18, 10:00 A. M.

165. Cleves, below, Great Miami River, Sept. 18, 7:30 A. M. Received Sept. 19, 8:00 A. M.

166. Linwood, below, Little Miami River, Sept. 18, 4:30 P. M. Received Sept. 20, 9:45 A. M.

167. Batavia, below, East Fork of Little Miami River, Sept. 19, 7:00 A. M. Received Sept 20, 9:45 A. M.

168. Batavia, above, East Fork of Little Miami River, Sept. 19, 8:00 A. M. Received Sept. 20, 9:45 A. M.

169. Hamilton, below, Great Miami River, Sept. 19, 12:30 P. M. Received Sept. 20, 9:45 A. M.

170. Hamilton, above, Great Miami River, Sept. 19, 1:30 P. M. Received Sept. 20, 9:45 A. M.

171. Middletown, below, Great Miami River, Sept. 19, 2:15 P. M. Received Sept. 20, 8:00 A. M.

172. Middletown, above, Great Miami River, Sept. 19, 3:00 P. M. Received Sept. 20, 8:00 A. M.

173. Sidney, below, Great Miami River, Oct. 1, 11:30 A. M. Received Oct. 3, 8:30 A. M.

174. Sidney, above, Great Miami River, Oct. 1, 12:45 P. M. Received Oct. 3, 8:30 A. M.

175. Piqua, above Great Miami River, Oct. 1, 2:15 P. M. Received Oct. 2, 9:00 A. M.

176. Piqua, below, Great Miami River, Oct. 1, 2:45 P. M. Received Oct. 2, 9:00 A. M.

177. Greenville, below, Greenville Creek, Oct. 1, 4:30 P. M. Received Oct. 3, 8:30 A. M.

178. Greenville, above, Greenville Creek, Oct. 1, 5:30 P. M. Received Oct. 3, 8:30 A. M.

179. Dayton, below, Great Miami River, Oct. 2, 7:45 A. M. Received Oct. 3, 8:30 A. M.

180. Dayton, above, Mad River, Oct. 2, 9:30 A. M. Received Oct. 3, 8:30 A. M.

181. Dayton, above, Great Miami River, Oct. 2, 10:45 A. M. Received Oct. 3, 8:30 A. M.

182. Dayton, above, Stillwater River, Oct. 2, 11:15 A. M. Received Oct. 3, 8:30 A. M.

183. Troy, below, Great Miami River, Oct. 2, 3:45 P. M. Received Oct. 4, 8:00 A. M.

184. Troy, above, Great Miami River, Oct. 2, 4:45 P. M. Received Oct. 4, 8:00 A. M.

185. Urbana, above, Mad River, Oct. 3, 7:45 A. M. Received Oct. 4, 8:00 A. M.

186. Urbana, below, Mad River, Oct. 3, 8:45 A. M. Received Oct. 4, 8:00 A. M.

187. Springfield, below, Mad River, Oct. 3, 11:30 A. M. Received Oct. 4, 8:00 A. M.

188. Springfield, above, Mad River, Oct. 3, 12:15 P. M. Received Oct. 4, 8:00 A. M.

189. Springfield, above, Buck Creek, Oct. 3, 2:30 P. M. Received Oct. 4, 8:00 A. M.

190. Middletown, above, Great Miami River, Oct. 13, 6:00 A. M. Received Oct. 15, 9:00 A. M.

191. Middletown, below, Great Miami River, Oct. 13, 6:45 A. M. Received Oct. 15, 9:00 A. M.

192. Hamilton, above, Great Miami River, Oct. 13, 8:30 A. M. Received Oct. 15, 8:00 A. M.

193. Hamilton, below, Great Miami River, Oct. 13, 9:30 A. M. Received Oct. 15, 8:00 A. M.

194. Cleves, below, Great Miami River, Oct. 13, 1:30 P. M. Received Oct. 15, 9:00 A. M.

195. Linwood, above, Little Miami River, Oct. 13, 4:00 P. M. Received Oct. 16, 9:45 A. M.

196. South Charleston, above, Little Miami River, Oct. 18, 8:30 A. M. Received Oct. 19, 9:30 A. M.

197. Xenia, above, Little Miami River, Oct. 18, 11:15 A. M. Received Oct. 19, 10:30 A. M.

198. Xenia, below, Little Miami River, Oct. 18, 11:45 A. M. Received Oct. 19, 10:30 A. M.

199. Loveland, above, Little Miami River, Oct. 19, 6:00 A. M. Received Oct. 20, 8:00 A. M.

200. Batavia, above, East Fork of Little Miami River, Oct. 19, 11:10 A. M. Received Oct. 20, 1:45 P. M.

201. Batavia, below, East Fork of Little Miami River, Oct. 19, 1:00 P. M. Received Oct. 20, 1:45 P. M.

202. Piqua above, Great Miami River, Nov. 1, 9:45 A. M. Received Nov. 2, 8:00 A. M.

203. Piqua, below, Great Miami River, Nov. 1, 10:15 A. M. Received Nov. 2, 8:00 A. M.

204. Sidney, below, Great Miami River, Nov. 1, 11:30 A. M. Received Nov. 3, 8:00 A. M.

205. Sidney, above, Great Miami River, Nov. 1, 1:15 P. M. Received Nov. 3, 8:00 A. M.

206. Greenville, above, Greenville Creek, Nov. 1, 4:30 P. M. Received Nov. 2, 8:00 A. M.

207. Greenville, below, Greenville Creek, Nov. 1, 5:00 P. M. Received Nov. 2, 8:00 A. M.

208. Dayton, below, Great Miami River, Nov. 2, 8:00 A. M. Receixved Nov. 3, 8:00 A. M.

209. Dayton, above, Mad River, Nov. 2, 9:15 A. M. Received Nov. 3, 8:00 A. M.

210. Dayton, above, Great Miami River, Nov. 2, 10:45 A. M. Received Nov. 3, 8:00 A. M.

211. Dayton, above, Stillwater River, Nov. 2, 11:15 A. M. Received Nov. 3, 8:00 A. M.

212. Troy, below, Great Miami River, Nov. 2, 3:45 P. M. Received Nov. 3, 8:00 A. M.

213. Troy, above, Great Miami River, Nov. 2, 4:45 P. M. Received Nov. 3, 8:00 A. M.

214. Springfield, below, Mad River, Nov. 3, 7:00 A. M. Received Nov. 3, 4:15 P. M.

215. Springfield, above, Mad River, Nov. 3, 7:45 A. M. Received Nov. 3, 4:15 P. M.

216. Springfield, above, Buck Creek, Nov. 3, 9:00 A. M. Received Nov. 5, 8:00 A. M.

217. Urbana, above, Mad River, Nov. 3, 11:30 A. M. Received Nov. 3, 5:00 P. M.

218. Urbana, below, Mad River, Nov. 3, 12:15 P. M. Received Nov. 3, 5:00 P. M.

219. South Charleston, above, Little Miami River, Nov. 7, 8:30 A. M. Received Nov. 8, 8:00 A. M.

220. Middletown, above, Great Miami River, Nov. 7, 1:45 P. M. Received Nov. 8, 8:00 A. M.

221. Middletown, below, Great Miami River, Nov. 7, 2:30 P. M. Received Nov. 8, 8:00 A. M.

222. Hamilton, above, Great Miami River, Nov. 7, 3:30 P. M. Received Nov. 8, 4:00 P. M.

223. Hamilton, below, Great Miami River, Nov. 7, 4:30 P. M. Received Nov. 8, 4:00 P. M.

224. Linwood, below, Little Miami River, Nov. 8, 7:30 A. M. Received Nov. 9, 8:00 A. M.

225. Batavia, above, East Fork of Little Miami River, Nov. 8, 9:30 A. M. Received Nov. 10, 10:00 A. M.

226. Batavia, below, East Fork of Little Miami River, Nov. 8, 10:30 A. M. Received Nov. 9, 8:00 A. M.

227. Cleves, below, Great Miami River, Nov. 8, 3:30 P. M. Received Nov. 9, 8:00 A. M.

228. Loveland, above, Little Miami River, Nov. 9, 7:30 A. M. Received Nov. 9, 2:15 P. M.

229. Xenia, below, Little Miami River, Nov. 9, 12:30 P. M. Received Nov. 10, 10:00 A. M.

230. Xenia, above, Little Miami River, Nov. 9, 1:15 P. M. Received Nov. 10, 10:00 A. M.

V. RAINFALL.

Since the character of a river water is greatly affected in many cases by the addition of surface washings, and since the presence of surface washings in the water of a stream is so largely dependent on weather conditions, it is essential in a study of this kind to take into consideration the time and amount of recent rainfalls. To that end the following rainfall table was compiled from the monthly reports of the Ohio section of the United States weather bureau.

The table includes the date and amount of rainfall for those observing stations of the weather bureau located upon the area drained by the Little Miami River, the Great Miami River, and their tributaries (except Whitwater River). The sum of the amounts given may not equal the total for that month, as precipitations of less than one-tenth inch have been omitted from the table.

For convenience the observing stations were grouped as follows:

Little Miami River basin.
- (a). Little Miami River.
- (b). East fork of Little Miami River.

Great Miami River basin.
- (a). Stillwater River (including Greenville Creek).
- (b). Mad River (including Buck Creek).
- (c). Great Miami River.

RAINFALL TABLE.

DAYS ON WHICH ONE-TENTH INCH OR MORE RAINFALL OCCURED.

LITTLE MIAMI RIVER BASIN.

Station.	April.	Rain.	May.	Rain.	June.	Rain.	July.	Rain.	August.	Rain.	September.	Rain.	October.	Rain.	November.	Rain.
Plattsburg	2	.25	8	.38	1	.10	5	.25	12	.10	3	.43	6	.45	1	.22
	11	.35	9	.38	2	.33	8	.10	16	.77	7	.37	7	1.55	8	.10
	17	.55	18	.12	8	.25	9	.10	20	.37	20	.12	23	.20	...	......
	18	.13	19	.10	21	.40	12	.60	21	.36	27	2.70	...	......	...	......
	21	.17	30	.30	24	.65	16	.15	24	.20	29	.50	...	......	...	......
	22	.10	31	.20	25	.40	17	.45	26	.55	...	......	...	......	...	......
	...	......	...	......	29	.15	18	1.75	27	.30	...	......	...	......	...	......
	...	......	...	......	30	.11	19	1.00	...	......	...	......	...	......	...	......
	...	......	...	......	...	......	24	.45	...	......	...	......	...	......	...	......
	...	......	...	......	...	......	25	.30	...	......	...	......	...	......	...	......
	...	......	...	......	...	......	30	.70	...	......	...	......	...	......	...	......
Total rainfall........	...	1.60	...	1.48	...	2.44	...	5.80	...	2.65	...	4.12	...	2.33	...	4.88
Departure from normal	...	—1.66	...	—2.23	...	—0.86	...	+1.59	...	+0.13	...	+1.29	...	+0.67	...	+1.35
Clifton	11	.56	8	.24	...	......	8	.20	12	.40	...	......	...	......	...	......
	17	.49	9	.50	...	......	12	.24	15	1.05	...	......	...	......	...	......
	21	.60	18	.65	...	......	16	.14	20	.70	...	......	...	......	...	......
	22	.20	19	.13	...	......	17	.52	21	.45	...	......	...	......	...	......
	...	......	28	.21	...	......	18	1.17	26	.52	...	......	...	......	...	......
	...	......	31	.18	...	......	19	2.08	27	.30	...	......	...	......	...	......
	...	......	...	......	...	......	25	.50	...	......	...	......	...	......	...	......
Total rainfall........	...	1.90	...	1.97	...	......	...	5.14	...	3.56	...	......	...	......	...	......
Departure from normal	...	......	...	......	...	......	...	+1.11	...	......	...	......	...	......	...	......

LITTLE MIAMI RIVER BASIN—Concluded.

Station.	April.	Rain.	May.	Rain.	June.	Rain.	July.	Rain.	August	Rain.	September.	Rain.	October.	Rain.	November.	Rain.
Cedarville	10	.58	8	.90	7	.16	7	.18	12	.98	3	.19	6	.43	1	.24
	17	.38	9	.39	8	.28	17	1.37	15	1.48	6	.13	7	1.13		
	18	.17	18	.15	14	.15	19	1.04	20	.42	20	.13	16	.10		
	20	.25	19	.27	21	.12	25	.66	25	.73	27	.30	23	.23		
	21	.38	27	.27	22	.15			26	.27						
	22	.28	28	.26	24	.85										
			29	.38	29	.37										
			31	.38												
Total rainfall	...	2.17	...	3.03	...	2.44	...	3.67	...	4.05	...	0.82	...	2.01	...	4.93
Departure from normal	...	—0.46	...	—1.03	...	—0.11	...	—0.78	...	+1.81	...	—1.60	...	+0.15	...	+1.34
Waynesville	11	.50	8	1.20	1	.25	6	.10	3	.66	3	.33	7	1.24	1	.23
	17	.67	9	.49	6	.28	8	.32	12	1.00	20	.13	23	.58		
	21	.12	18	1.30	15	.10	16	.24	14	.40	29	.37	30	.27		
	22	.14	19	.63	22	.39	17	.15	15	.27						
			25	.20	24	.35	18	1.04	16	1.70						
			27	.65	28	.25	19	1.38	20	.20						
			28	.61	29	.47	20	.41	21	.10						
			29	.45			24	.56	23	.20						
			31	.33			25	.82	24	.10						
									25	1.50						
									26	.15						
									27	.25						
Total rainfall	...	1.66	...	5.94	...	2.15	...	5.12	...	6.56	...	0.88	...	2.16	...	3.63
Departure from normal	...	—1.56	...	+2.17	...	—1.86	...	+2.75	...	+2.66	...	—1.96	...	+0.19	...	+0.12
Clarksville	11	.49	8	.28	1	.10	8	.24	3	.29	20	.14	7	1.30	1	.25
	17	.36	9	.93	2	.47	16	.66	12	.77	29	.16	22	.10	8	.12
	18	.10	18	.15	6	.21	18	.82	14	1.71			23	.21		
	21	.62	19	.47	7	.11	19	.48	15	.14						
			27	.23	8	.47	24	.13	16	1.04						
			28	.63	22	.19	25	1.27	20	.16						
			30	.45	24	.26			25	.23						
			31	.23	28	.47			26	.19						
					29	.25			27	.41						
Total rainfall	...	1.77	...	3.19	...	2.86	...	3.99	...	5.17	...	0.42	...	1.67	...	5.37
Departure from normal	...	—1.85	...	—0.16	...	—1.33	...	+0.76	..	+1.59	...	—1.94	...	—0.24	...	+1.61
Camp Dennison	11	.53	8	.50	1	.10	3	.35	3	1.62	3	.30	7	1.12	1	.17
	17	.45	9	1.46	6	.54	8	.25	12	.20	20	.22	23	.42	8	.10
			18	2.17	14	.11	16	.14	14	.13						
			19	.30	26	.28	17	.30	16	.53						
			21	.20	28	.23	18	1.09	20	.11						
			28	1.17			19	.39	23	.36						
			30	.24			22	.15	24	.31						
			31	.22			25	1.50	25	.48						
							29	.14	26	.12						
									27	.17						
Total rainfall	...	1.37	...	6.39	...	1.49	...	4.43	..	4.18	...	0.68	...	1.72	...	5.39
Departure from normal	...	—1.86	...	+2.95	...	—1.66	...	+1.15	...	+1.56	...	—1.17	...	+0.19	...	+1.63

EAST FORK OF LITTLE MIAMI RIVER.

Station.	April.	Rain.	May.	Rain.	June.	Rain.	July.	Rain.	August.	Rain.	September.	Rain.	October.	Rain.	November.	Rain.
*Hillsboro	2	.12	8	.32	1	.16	3	.26	3	.18	3	1.20	7	.35	1	.22
	11	.37	9	.83	7	.25	8	.60	12	.69	20	.30	22	.46	8	.15
	17	.55	18	.40	14	.34	16	.80	16	1.50	29	.45	23	.94	...	......
	21	.10	19	.25	22	.13	17	.84	17	.15	...	......	...	......	...	......
	...	......	28	.85	25	.58	18	1.09	20	.30	...	......	...	......	...	......
	...	......	29	.17	26	.54	22	.38	26	.67	...	......	...	......	...	......
	...	......	...	......	28	.25	25	.57	...	......	...	......	...	......	...	......
	...	......	...	......	29	.27	...	......	...	......	...	......	...	......	...	......
Total rainfall........	...	1.27	...	2.02	...	2.35	...	4.82	...	3.64	...	2.11	...	1.75	...	5.80
Departure from normal	...	—1.06	...	+0.08	...	—0.80	...	+1.01	...	+0.61	...	+0.02	...	+0.17	...	+2.42
*New Richmond......	11	.56	6	.10	1	.12	3	.10	3	2.37	16	.11	7	1.82	1	.18
	17	.53	8	.21	7	.25	6	.17	12	.22	20	.14	23	.27	8	.10
	20	.13	9	.91	22	.30	8	.36	13	.16	29	.43	...	......	...	......
	...	......	19	.57	30	.13	16	.40	14	.20	...	......	...	......	...	......
	...	......	28	.65	...	......	18	.17	16	.15	...	......	...	......	...	......
	...	......	29	.71	...	......	19	.12	22	.32	...	......	...	......	...	......
	...	......	30	.30	...	......	21	.12	26	1.24	...	......	...	......	...	......
	...	......	31	.31	...	......	22	.34	27	.27	...	......	...	......	...	......
	...	......	...	......	...	......	25	1.15	...	......	...	......	...	......	...	......
	...	......	...	......	...	......	29	.20	...	......	...	......	...	......	...	......
Total rainfall........	...	1.36	...	3.87	...	1.05	...	3.18	...	5.03	...	0.82	...	2.24	...	5.78
Departure from normal	...	......	...	......	...	......	...	......	...	......	...	......	...	......	...	......
Average rainfall for the basin	...	1.64	...	3.64	...	2.10	...	4.52	...	4.35	...	1.10	..	1.98	..	5.11
Departure from normal for basin .	...	—1.46	...	+0.30	...	—1.10	...	+1.08	...	+1.39	...	—0.89	.	+0.19	...	+1.39

GREAT MIAMI BASIN.

a. STILLWATER RIVER.

Greenville	11	.60	8	.34	1	1.57	2	.11	2	.36	20	.43	6	.60	1	.26
	16	.10	9	.35	21	.20	7	.18	3	.45	27	.87	7	1.05	...	......
	17	1.17	18	.60	22	.42	8	.23	12	.20	29	2.35	22	.35	...	......
	...	......	19	.62	24	.29	12	.13	14	.18	...	......	...	......	...	......
	...	......	27	.23	25	.92	16	.25	15	.84	...	......	...	......	...	......
	...	......	28	.62	29	.42	17	.50	16	.47	...	......	...	......	...	......
	...	......	29	.17	...	......	19	.31	20	.18	...	......	...	......	...	......
	...	......	31	.98	...	......	23	.15	21	.24	...	......	...	......	...	......
	...	......	...	......	...	......	24	.11	...	......	...	......	...	......	...	......
	...	......	...	......	...	......	25	.33	...	......	...	......	...	......	...	......
	...	......	...	......	...	......	29	.87	...	......	...	......	...	......	...	......
Total rainfall........	...	1.90	...	3.87	...	4.09	...	3.61	...	3.13	...	3.65	...	2.03	...	3.62
Departure from normal	...	—1.43	...	—0.34	...	—0.12	...	+0.60	...	—0.41	...	+0.91	...	+0.27	...	—0.33

b. MAD RIVER.

Urbana	11	.64	9	.67	1	.76	7	.40	3	.11	3	.10	7	1.40	1	.20
	13	.10	18	.86	6	.15	11	.31	15	.35	6	.93	22	.15	...	......
	16	.11	27	.36	7	.56	16	.30	16	.83	28	.39	23	.44	...	......
	17	.57	28	.20	21	1.04	17	1.00	19	.28	29	.92	...	......	...	......
	21	.45	31	.32	22	.79	19	.10	20	.13	...	......	...	......	...	......
	22	.15	...	......	29	.55	25	.22	21	.27	...	......	...	......	...	......
	...	......	...	......	...	......	...	......	23	.40	...	......	...	......	...	......
	...	......	...	......	...	......	...	......	26	.75	...	......	...	......	...	......
	...	......	...	......	...	......	...	......	26	.15	...	......	...	......	...	......
Total rainfall........	...	2.02	...	2.36	...	4.00	...	2.42	...	3.33	...	2.39	...	1.99	...	3.68
Departure from normal	...	0.00	...	—1.04	...	+0.77	...	—2.67	...	+0.95	...	—0.82	...	+0.18	...	—0.11

---

*Hillsboro and New Richmond are situated just outside of the watershed of the Little Miami River, but use is made of the data from these stations as there was no weather bureau station on the territory drained by the East Fork of Little Miami River.

b. MAD RIVER — Concluded.

Station.	April.	Rain.	May.	Rain.	June.	Rain.	July.	Rain.	August.	Rain.	September.	Rain.	October.	Rain.	November.	Rain.
*Springfield	11	.64	8	.66	1	.32	8	.33	15	.36	3	.15	6	.30	1	.23
	17	.57	9	.28	2	.34	12	.43	16	1.02	7	.24	7	.80	...	......
	21	.63	18	1.36	6	.11	16	.14	20	.59	27	1.01	23	.41	...	......
	22	.13	19	.13	21	.72	18	.93	21	.64	29	.62	...	......	...	......
	...	......	31	.26	22	.29	19	1.31	24	.80	...	......	...	......	...	......
	...	......	...	......	24	1.43	25	.24	26	.16	...	......	...	......	...	......
	...	......	...	......	25	.23	30	.15	27	.25	...	......	...	......	...	......
	...	......	...	......	29	.44	...	......	...	......	...	......	...	......	...	......
Total rainfall	...	2.00	...	2.89	...	4.06	...	3.72	...	3.88	...	2.10	...	1.64	...	3.60
Departure from normal	...	......	...	......	...	......	...	......	...	......	...	......	...	......	...	......

c. GREAT MIAMI RIVER.

Bellefontaine	12	1.65	...	......	1	.30	8	.45	3	.10	4	.20	7	2.05	...	......
	14	.10	...	......	2	.50	12	1.10	16	1.00	7	.11	16	.10	...	......
	18	.71	...	......	7	.17	17	.17	20	.35	21	.70	23	.63	...	......
	22	.25	...	......	8	.50	18	.43	21	.45	28	.20	...	......	...	......
	...	......	...	......	9	.26	20	.28	24	1.20	29	1.30	...	......	...	......
	...	......	...	......	22	.55	25	.98	26	.23	...	......	...	......	...	......
	...	......	...	......	23	1.05	30	.18	27	.10	...	......	...	......	...	......
	...	......	...	......	25	2.10	...	......	...	......	...	......	...	......	...	......
	...	......	...	......	30	.22	...	......	...	......	...	......	...	......	...	......
Total rainfall	...	2.78	...	......	...	5.65	...	3.76	...	3.43	...	2.64	...	2.78	...	2.76
Departure from normal	...	+0.09	...	......	...	+1.93	...	+0.92	...	+0.92	...	—0.18	...	+0.38	...	—1.08
Rosewood	1	.24	8	.21	1	.47	...	......	3	.22	3	.16	6	.19	1	.18
	11	.63	9	.23	2	.11	...	......	15	.67	6	.41	7	2.01	...	......
	13	.13	18	.60	9	.16	...	......	16	1.40	8	.45	22	.51	...	......
	16	.10	19	.11	10	.24	...	......	20	.48	20	.46	30	.22	...	......
	17	.83	25	.11	21	.45	...	......	21	.65	27	.34	...	......	...	......
	21	.11	27	.26	22	.26	...	......	23	.49	28	.25	...	......	...	......
	...	......	28	.15	24	.63	...	......	25	.52	29	1.35	...	......	...	......
	...	......	29	.14	29	.18	...	......	26	.20	...	......	...	......	...	......
	...	......	31	.21	...	......	...	......	27	.30	...	......	...	......	...	......
Total rainfall	...	2.04	...	2.02	...	2.56	...	......	...	4.91	...	3.41	...	3.01	...	3.54
Departure from normal	...	—0.46	...	—1.22	...	+0.16	...	......	...	+1.96	...	+0.73	...	+1.24	...	—0.30
Sidney	12	.65	9	.38	1	.37	8	.40	3	.25	7	.17	7	3.10	...	......
	17	.12	19	.74	2	.65	17	.57	13	.21	9	.35	8	.37	...	......
	18	.65	28	.36	6	.19	18	.52	16	1.11	21	.23	17	.12	...	......
	22	.14	29	.35	7	.66	20	.21	20	.54	28	.49	23	1.48	...	......
	...	......	...	......	21	.31	21	.21	21	.64	29	1.17	31	.10	...	......
	...	......	...	......	22	.35	25	.45	24	.38	...	......	...	......	...	......
	...	......	...	......	24	.58	...	......	25	.14	...	......	...	......	...	......
	...	......	...	......	26	.12	...	......	27	.49	...	......	...	......	...	......
Total rainfall	...	1.80	...	1.90	...	3.82	...	2.70	...	3.98	...	2.53	...	5.21	...	3.08
Departure from normal	...	......	...	......	...	......	...	......	...	......	...	+0.27	...	......	...	......
Dayton	11	.70	8	.49	1	.34	8	.40	2	.13	3	.19	6	.98	1	.18
	17	.30	9	.33	2	.16	12	.21	3	.62	9	.16	7	1.45	...	......
	...	......	18	.43	6	.58	16	.42	14	.18	20	.13	22	.16	...	......
	...	......	19	.37	14	.10	18	.39	15	.50	27	.11	23	.70	...	......
	...	......	24	.11	21	.34	19	.74	16	1.35	29	.38	...	......	...	......
			24	.43	22	.88	20	.11								
			25	.53	25	.51	23	.17								
	...	......	27	.43	24	.43	22	.88	20	.11	...	......	...	......	...	......
	...	......	28	.27	25	.53	25	.61	23	.17	...	......	...	......	...	......
	...	......	31	.33	26	.50	...	......	25	1.17	...	......	...	......	...	......
	...	......	...	......	29	.86	...	......	26	.16	...	......	...	......	...	......
	...	......	...	......	...	......	...	......	27	.16	...	......	...	......	...	......
Total rainfall	...	1.23	...	2.79	...	3.96	...	3.81	...	4.66	...	0.99	...	3.36	...	3.60
Departure from normal	...	—1.70	...	—1.05	...	0.00	...	+0.89	...	+1.62	...	—1.71	...	+1.32	...	+0.21

---

* The record of precipitation at Springfield was obtained from Mr. W. C. Powell, chief engineer of waterworks, and was kindly furnished to us from his private record-book.

c. GREAT MIAMI RIVER—Concluded.

Station.	April	Rain.	May.	Rain.	June	Rain	July.	Rain	August.	Rain.	September.	Rain.	October.	Rain.	November	Rain.
New Paris	11	.84	8	.16	1	1.61	2	.36	2	.30	20	.24	6	.10	1	.70
	16	.10	9	.45	6	.22	8	.80	3	.16	27	.35	7	1.25	...	......
	17	.51	18	.58	11	.42	12	.55	12	.12	29	.45	23	.22	...	......
	22	.14	19	.89	21	1.02	16	.62	14	.29	...	......	...	......	...	......
	...	......	23	.33	22	.26	17	.44	15	1.11	...	......	...	......	...	......
	...	......	27	1.30	24	1.07	18	.33	16	.21	...	......	..	......	...	......
	...	......	25	.61	25	.75	19	.60	20	.34	...	......	..	......	...	......
	...	......	29	.58	26	.53	20	.22	25	.80	...	......	...	......	...	......
	...	......	31	.70	29	.67	25	.50	...	......	...	......	...	......	...	......
	..	......	...	......	...	......	29	.58	...	......	...	......	...	......	...	......
Total rainfall	...	1.65	...	5.71	...	6.64	...	5.08	...	3.38	...	1.04	...	1.57	...	3.76
Departure from normal	...	—0.54	..	+3.04	...	+2.92	...	+2.83	...	—0.61	...	—1.93	...	—0.12	...	—1.00
Springboro	11	.46	8	1.43	2	.25	2	.50	3	.79	3	.60	5	.90	2	.25
	14	.30	18	.22	7	.58	3	.11	13	1.10	20	.20	6	1.06	...	......
	16	.80	19	.48	16	.22	8	.47	14	1.45	29	.20	21	.50	...	......
	17	.32	28	.98	24	.22	16	.35	20	.20	...	......	22	.59	...	......
	20	.30	29	.16	29	1.51	17	1.99	22	.15	...	......	30	.64	...	......
	...	......	31	.41	30	.33	19	1.10	25	1.18	...	......	...	......	...	......
	...	......	...	......	...	......	24	.10	26	.18	...	......	...	......	...	......
	...	......	...	......	...	......	25	.96	...	......	...	......	...	......	...	......
Total rainfall	...	2.18	...	3.68	...	3.11	...	5.58	...	5.05	...	1.00	...	3.69	...	3.53
Departure from normal	...	......	...	......	...	......	...	......	...	......	...	......	...	......	...	......
Jacksonboro	11	.60	9	.85	1	.50	2	.25	3	.75	3	.25	7	1.25	1	.15
	17	1.00	19	.50	6	.25	5	.10	12	.10	6	.10	22	.40	...	......
	22	.10	27	1.00	14	.15	7	.46	13	.10	8	......	30	.40	...	......
	...	......	28	.10	21	.15	11	.10	14	.10	...	......	...	......	...	......
	...	......	29	1.00	22	.15	16	.25	16	.40	...	......	...	......	...	......
	...	......	30	.25	24	.10	17	.20	20	.15	...	......	...	......	...	......
	...	......	31	.10	25	.50	18	.75	25	1.00	...	......	...	......	...	......
	...	......	...	......	28	.75	19	.10	26	.25	...	......	...	......	...	......
	...	......	...	......	...	......	24	1.00	...	......	...	......	...	......	...	......
Total rainfall	...	1.75	...	3.80	...	2.66	...	3.40	...	2.90	...	0.45	...	2.05	...	2.75
Departure from normal	...	—1.07	...	+1.02	...	—1.10	...	+1.23	...	+0.16	...	—1.95	...	+0.50	...	—0.56
Bethany	11	.48	8	.65	1	.42	2	.25	3	1.54	3	.14	6	.48	1	.25
	16	.16	18	.26	6	1.34	4	.23	12	.14	7	.10	7	.95	...	......
	17	.45	19	.34	7	.78	6	.12	14	.60	29	.44	22	.54	...	......
	18	.14	27	1.96	14	.27	7	.22	15	.36	...	......	...	......	...	......
	...	......	28	.30	15	.37	16	.52	23	.65	...	......	...	......	...	......
	...	......	29	.40	24	1.04	17	1.22	25	.63	...	......	...	......	...	......
	...	......	30	.26	26	.16	18	.17	26	.10	...	......	...	......	...	......
	...	......	31	.25	28	.33	19	.35	...	......	...	......	...	......	...	......
	...	......	...	......	29	.10	25	.97	...	......	...	......	...	......	...	......
Total rainfall	...	1.33	...	4.48	...	4.94	...	4.24	...	4.02	...	0.81	...	1.97	...	4.47
Departure from normal	...	—1.40	...	+0.99	...	+1.99	...	+0.07	...	+0.97	...	—1.57	...	+0.53	...	+1.00
Average rainfall for basin	...	1.88	...	3.35	...	4.13	...	3.83	...	3.87	...	1.91	...	2.66	...	3.49
Departure from normal for basin	...	—0.82	...	+0.20	...	+0.82	...	+0.57	...	+0.69	...	—0.69	...	+0.54	...	—0.27

The following general statements were also gathered from the monthly reports of the weather bureau:

April. The temperature for the month was nearly normal, the average departure being but —0.5° F. for the state. However, the month was dry, as the average deficiency in rainfall was 1.01 inches

(1.67 inches for the southern section of the state). Very little rain fell during the first ten days of April and only traces after the 23rd.

May. The average temperature for the month was 1.9° F. above the normal. The average deficiency in rainfall for the state was 1.07 inches, but the deficiency for the southern section was only .06 inches, and that of the middle section 1.75 inches. The last ten days of the month were warm and general rains occurred from the twenty-seventh on.

June. The average temperature was 0.5° F. below the normal. The average rainfall showed a deficiency of .42 inches for the state, and deficiencies of .16 and .61 inches respectively for the middle and southern sections.

July. The temperature showed an excess of .4° F. The excess of rainfall for the state was .73 inches, but the middle and southern sections showed deficiencies of .45 and .12 inches, respectively.

August. The month was hot and rather wet. This was the hottest August save one for eighteen years. The average excess of temperature was 5.0° F The departures from the normal rainfall were + .77, + .95 and + .36 inches, respectively, for the state, the middle section, and the southern section.

September. This month was hot and dry. In the last eighteen years only one September has shown a higher mean daily temperature. The departures from the normal temperature were + 3.7 and + 4.5 for the state and the southern section of the state. The coolest spell in the month was from the 17th to the 19th. The rainfall departures from the normal were —.88, —.63 and — 1.24 inches for the state, the middle and the southern sections.

October. The average excess of temperature was 8.0° F. The mean daily temperature for the state during the month was 2.4° higher than for any other October in the past eighteen years. The rainfall showed departures of —.22, —.05, and —.40 inches for the state, the middle and the southern sections. Thus it is seen the month was a warm one for the time of year and drier than usual.

November. The excess of temperature was 1.0°., and that of precipitation .86 inches, but as only light rains fell on the 1st, 7th, and 8th, while the heavier ones did not begin until the 20th, that portion of the month concerned in this study was dry for November.

WEATHER HISTORY OF SAMPLES.

From the preceding rainfall table and general statements, we derive the following weather history of the various samples taken.

a.— LITTLE MIAMI RIVER.

April. Samples were taken on the 24th, 25th, and 26th of the month during a period of fair weather. While the rainfall for the month was deficient, the most of it occurred between the 11th and 22d, and thus the samples do not follow an unusual April period.

May. Samples were taken on the 28th and 29th. (The Batavia samples were taken June 1st). This had been a rather dry May until the general rain covering the last five days of the month. Therefore the samples were taken in a warm period and during the rainiest portion of the month.

June. These collections were made on the 26th-28th of the month, during a period of general rains of light to medium intensity. There was a small deficiency in the precipitation for the month, but the rain was fairly well distributed.

July. Samples were collected July 17, 19 and 20. The sampling occurred during one(and the heavier one) of the two periods of general soaking rains of the month. The weather bureau stations on the Little Miami watershed, as shown in the rainfall table, recorded daily precipitations from light rains to as heavy as 2.08 inches. Previous to the 16th of the month there had been a few days of bright clear weather.

August. Collections were made on the 20th-22d of the month, during a wet hot period. Showers had been frequent since the 11th of the month. The samples from the southern portion of the watershed represent the stream at it was returning to normal, after a summer flood.

September. Samples were taken September 17-19. The month of September showed the least rainfall for the watershed of any month during our studies on the Little Miami River, and as the precipitation occurred chiefly on the 3d and 6th, and after the 19th, the samples represent the streams after a hot dry period in the early fall.

October. Samples were taken October 13th, 18th and 19th. In this unusually hot October the rainfall was deficient, and as the precipitation on the area drained by the Little Miami River fell chiefly on the 7th, 22d and 23d of the month, these samples represent the water during another period of hot dry weather in the fall.

November. Samples were taken on the 7th to the 9th of the month. The cold fall rains did not begin until later, and as only very light rains fell on this watershed on the 1st and 8th, and also on October 30th, the samples were taken after two weeks of warm fair weather in the late fall.

b.— GREAT MIAMI RIVER.

As there were twenty-two sampling stations on this watershed it was found more convenient to make part of the collections at the same time with the Little Miami samples. Accordingly the samples from the southern portion of the watershed were collected on a different trip each month than those from the northern portion. In speaking of the southern samples reference is made to those from Middletown, Hamilton and Cleves, while by the northern samples those are designated which come from Dayton and points farther north, viz.: Troy, Piqua, Sidney, Greenville, Springfield and Urbana.

April. The northern samples were taken April 16-19; the southern April 25-26. The early portion of the month was dry, but beginning on the 11th frequent showers occurred on the watershed up to and including the 22d, after which the weather was fair. The heaviest rain of the month fell on or near the 17th, one of the sampling days. The streams were somewhat disturbed by surface washings at the first sampling period.

May. The northern samples were collected May 22-24; the southern on the 28th and 29th. The collections of the former trip were made during a fair weather period preceding a few days by moderate rains. From the 27th to the 29th there was a general rain on the watershed and as a result the southern samples showed disturbances.

June. Northern collections, June 18-20. Southern collections June 27-28. Light to moderate rains fell during the early part of the month, but after the 9th no rain of moment fell on the area affecting the northern samples, and accordingly they represent the streams after a period of dry clear weather in the early summer. Although no rain fell during the second sampling period, yet the southern samples showed the influence of the light, moderate and heavy rains which had fallen during the six days previous to this trip.

July. Northern samples were taken July 9-11; the southern July 19-20. The first set of collections represent no unusual conditions, but those of the second set (southern samples) showed some disturbances, as rains were general from the 16th to the 19th of the month, and one day's precipitation was recorded as high as 2 inches.

August. Sampling periods were on the 7th-9th, for the north, and 21st-22d for the south. In general only very light rains fell at the opening of the month, otherwise the first ten days were dry. Accordingly the earlier samples represented the northern streams during a fair weather period of unusual heat. Rains of varying intensities fell in the interval between the two sampling periods, and the later samples do not stand for as dry conditions, although the weather was still hot.

September. The northern samples were taken on the 3rd, 4th, and 5th of the month, the southern samples on the 18th and 19th. Very light rains were recorded at some stations on the 3d, but the northern samples represented fair weather samples after a week of hot clear weather. The southern collections were made during the coolest period of the month, and after a fair weather period of about three weeks, in which time the only rainfall of moment was recorded at Urbana on the 6th.

October. Samples for the northern section were taken on the first three days of the month; the southern ones on the 13th. In both cases the weather was fair at the time of sampling, but heavy rains had fallen on the 7th of October, as well as during the last week of September, and therefore the October samples revealed the character of the water in mild fall weather from three to six days after heavy rains.

November. Northern sampling period November 1-3. Southern sampling period November 7-8. As the fall rains began later, and only a very light rain fell on the 1st or 2d, these samples represent warm dry weather conditions for the season of year.

VI. RESULTS OF EXAMINATIONS.

The analytical results obtained from the examinations of the samples taken monthly from April to November, 1900, inclusive, are given first in tabulated form and later by plotted curves. In the table, the first column gives the laboratory number of the sample; the second, the serial number of the sample as collected; the third, the approximate distance in miles by river from the station to the mouth of the Little Miami River or the Great Miami River, as the case may be; the fourth, the locality or source of sample; the fifth, the date of collection; and the remaining columns give the analytical findings which are expressed in parts per million, except for color, turbidity, bacteria and temperature. The color is expressed in terms of the cobalt-platinum standard; the turbidity in terms of the platinum wire scale; the bacteria in number per cubic centimeter of the water; and the temperature in degrees Centigrade.

The abbreviations used for designating the amount of sediment are as follows: Very slight, v. s.; slight, s.; considerable, c.; much, m.

Turbidity readings marked *, indicate that the end of the turbidity stick rested on the bed of the river with the wire still plainly visible. When the number of bacteria is marked *, it indicates the count was low owing to interference from overspreading growths.

RECORD OF CHEMICAL AND BACTERIOLOGICAL EXAMINATIONS

LITTLE MIAMI WATERSHED.

a LITTLE MIAMI RIVER. [Parts per

Sample number.	Serial number.	Approximate distances.	Locality of sample.	Date collected.	Color.	Turbidity.	Sediment.	Odor.
.....	.....	90	South Charleston, above	April	.....	.....	.....	Not taken.
1128	46	....	"	May 28	.26	.13	S.	Earthy.
1196	75	....	"	June 26	.40	.34	C.	Vegetative.
1234	107	....	"	July 17	.30	.30	C.	"
1288	133	....	"	Aug. 20	.30	.31	C.	Earthy.
.....	.....	....		....	.....	.....	.....	Water not fl'g.
1436	196	....	"	Oct. 18	.23	.24	C.	Vegetative.
1485	219	....	"	Nov. 7	.29	.25	C.	Veg., earthy.
			AVERAGE	....	.30	.26	......	....
1071	27	69	Xenia, above town.	April 26	.20	.12	S.	Vegetative.
1126	47	....	" "	May 28	.28	.20	C.	"
1202	85	....	" "	June 28	.33	.40	C.	"
1236	105	....	" "	July 17	.30	.34	C.	Marked veg.
1310	143	....	" "	Aug. 22	.43	.27	C.	Vegetative.
1358	162	....	" "	Sept. 17	.16	.14	S.	"
1437	197	....	" "	Oct. 18	.35	.13	C.	Faint musty.
1502	230	....	" "	Nov. 9	.65	.08	S.	Vegetative.
			AVERAGE	....	.34	.21	......	....
1072	28	68	Xenia, below town.	April 26	.26	.12	S.	Marked veg.
1127	48	....	" "	May 28	.32	.22	C.	Vegetative.
1203	86	....	" "	June 28	.33	.40	C.	"
1235	104	....	" "	July 17	.28	.26	C.	Marked veg.
1311	144	....	" "	Aug. 22	.38	.23	C.	Vegetative.
1359	163	....	" "	Sept. 17	.17	.15	S.	"
1438	198	....	" "	Oct. 18	.33	.14	C.	Faint musty.
1501	229	....	" "	Nov. 9	.58	.10	S.	Vegetative.
			AVERAGE	....	.33	.20	......	....
1062	18	20	Loveland, above town	April 24	.18	.11	C.	Marked veg.
1131	55	....	"	May 29	.30	.75	M.	Earthy.
1197	76	....	"	June 26	.15	.52	C.	Faint sour.
1233	106	....	"	July 17	.13	.50	C.	Vegetative.
1289	134	....	"	Aug. 20	.33	1.05	C.	Earthy, veg.
1360	164	....	"	Sept. 17	.20	.26	S.	Earthy.
1439	199	....	"	Oct. 19	.18	.23	C.	Vegetative.
1498	228	....	"	Nov. 9	.26	.16	S.	Earthy.
			AVERAGE	....	.22	.45	......	....

OF THE GREAT AND LITTLE MIAMI RIVERS AND TRIBUTARIES.

LITTLE MIAMI WATERSHED.

Million.)

a LITTLE MIAMI RIVER.

Oxygen required.	Nitrogen as				Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen.	Bacteria per c. c.	Temperature °C.
	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.								
5.04	.200	.138	.042	1.24	T	225.8	66.0	354	134	6.10	3800	18.0
9.15	.442	.262	.090	.66	T	239.4	39.8	390	125	4.90	2200	24.5
9.81	.522	.230	.022	.06	1.5	290.2	7.4	438	181	5.33	3800	28.0
9.98	.540	.156	.018	T	None	221.8	36.2	349	98	3.20	2800	24.5
4.98	.242	.080	.013	None	None	223.2	None	362	128	9.00	3400	8.0
5.86	.356	.112	.018	None	4.0	266.8	None	423	123	8.75	3000	8.0
7.47	.384	.163	.034	.33	.9	244.5	24.9	386	132	6.21	3266	.....
4.89	.220	.032	.028	1.17	1.1	223.8	18.4	335	127	11.50	44400	18.0
5.83	.270	.230	.034	.70	.5	234.8	27.8	396	152	6.03	121100	20.0
6.29	.314	.174	.038	.67	.8	250.8	None	423	119	6.17	4900	25.0
8.31	.794	.280	.056	.03	.7	260.8	None	374	155	11.00	1700	27.0
6.11	.296	.090	.030	.02	T	230.2	22.2	369	118	5.73	174200	26.5
3.71	.226	.066	.012	.06	1.4	235.8	None	315	114	8.25	3200	18.5
8.50	.302	.136	.007	T	.8	269.8	None	386	153	8.30	180000	12.5
8.89	.306	.006	.008	.12	1.9	287.2	None	368	127	8.80	80000	6.0
6.57	.341	.127	.027	.35	.9	249.1	8.5	371	133	8.22	76187	.....
6.19	.286	.020	.032	1.28	1.6	240.2	13.8	362	145	9.70	62400	18.0
5.53	.292	.310	.058	.89	4.3	254.4	7.0	418	165	5.40	11800	20.0
5.49	.328	.180	.036	1.04	2.2	221.6	32.2	383	108	6.21	5100	25.5
5.55	.314	.142	.032	.36	3.2	256.6	None	375	154	9.21	1200	26.5
7.33	.462	.070	.030	T	.8	236.8	None	344	118	6.22	177000	27.5
4.20	.282	.078	.022	T	1.9	242.4	None	388	113	8.90	2600	19.5
6.64	.212	.134	.009	T	1.7	252.4	None	380	145	7.60	34400	12.5
7.01	.324	.050	.010	.10	2.6	281.0	None	378	121	8.72	148000	6.5
5.99	.312	.123	.029	.46	2.3	248.2	6.6	378	134	7.74	55312	.....
4.13	.216	.036	.011	1.26	1.1	194.2	20.2	316	122	9.70	1800	17.0
7.02	.332	.076	.018	.52	.8	157.6	15.2	483	91	7.62	21000	22.0
5.05	.324	.096	.009	.40	2.2	238.8	12.4	389	64	8.30	1500	28.5
4.11	.254	.066	.026	.30	2.6	219.6	11.2	350	117	7.82	1200	29.0
7.13	.312	.124	.024	.31	None	128.2	20.6	338	65	6.57	8000	29.5
4.61	.321	.036	.006	None	2.8	210.0	None	316	60	9.90	1900	20.0
3.62	.220	.032	.006	None	2.9	224.0	None	378	119	9.50	2100	13.0
2.79	.176	.022	.010	T	2.7	231.2	None	343	118	10.40	1400	6.5
4.81	.269	.061	.014	.35	1.9	200.4	9.9	364	94	8.73	4862	.....

RECORD OF CHEMICAL AND BACTERIOLOGICAL EXAMINATIONS OF

a LITTLE MIAMI RIVER—Concluded.

Parts Per

Sample number.	Serial number.	Approximate distances.	Locality of sample.	Date collected.	Color.	Turbidity.	Sediment.	Odor.
1063	19	3	Linwood, below t'n	April 24	.13	.10	C.	Vegetative.
1134	54	....	"	May 29	.25	5.20	M.	Earthy.
1198	77	....	"	June 26	.23	.42	C.	Vegetative
1244	112	....	"	July 19	.25	7.00	M.	Earthy.
1294	135	....	"	Aug. 20	.23	1.20	C.	"
1368	166	....	"	Sept. 18	.22	.30	S.	Earthy, veg.
1432	195	....	"	Oct. 13	.32	.45	C.	Earthy.
1495	224	....	"	Nov. 8	.17	.11	S.	Earthy.
			AVERAGE	....	.22	1.85	......	....

b. EAST FORK OF LITTLE MIAMI RIVER.

Sample number.	Serial number.	Approximate distances.	Locality of sample.	Date collected.	Color.	Turbidity.	Sediment.	Odor.
1064	20	25	Batavia, above town	April 25	.25	.17	C.	Faint earthy.
1136	57	....	" "	June 1	.33	.24	C.	Vegetative.
1199	78	....	" "	June 27	.25	.18	S.	"
1246	114	....	" "	July 20	.25	.22	C.	Sour.
1297	137	....	" "	Aug. 21	.28	1.14	C.	Earthy.
1370	168	....	" "	Sept. 19	.23	.28	S.	Vegetative.
1443	200	....	" "	Oct. 19	.28	.38	C.	"
1500	225	....	" "	Nov. 8	.28	.18	S.	Faint veg've.
			AVERAGE	....	.27	.35	......	....
1065	21	23	Batavia, below t'n.	April 25	.25	.16	C.	Faint earthy.
1137	.....	....	" "	June 1	.33	.24	C.	Vegetative.
1200	79	....	" "	June 27	.28	.18	S.	"
1245	113	....	" "	July 20	.25	.20	C.	"
1296	136	....	" "	Aug. 21	.28	1.12	C.	Earthy.
1369	167	....	" "	Sept. 19	.23	.27	S.	Vegetative.
1444	201	....	" "	Oct. 19	.32	.38	C.	"
1496	226	....	" "	Nov. 8	.25	.17	S.	Faint musty.
			AVERAGE	....	.27	.34	......	....

GREAT AND LITTLE MIAMI RIVERS AND TRIBUTARIES — Continued.

Million.

a LITTLE MIAMI RIVER — Concluded.

Oxygen required.	Nitrogen as				Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen.	Bacteria per c. c.	Temperature °C.
	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.								
3.73	.192	.042	.010	.57	2.6	190.6	19.4	308	119	10.65	6100	18.5
14.75	.638	.097	.010	.18	.5	106.6	26.4	1529	149	8.03	30000	21.5
4.13	.260	.118	.006	.08	3.2	212.8	3.0	345	92	8.05	3000	28.0
19.66	.658	.134	.014	.10	1.3	127.6	25.2	1913	183	6.50	43000	27.5
6.45	.246	.068	.022	.10	T	108.2	None	352	62	6.70	7300	30.0
4.20	.370	.076	.006	T	3.4	205.8	None	326	59	10.89	1300	21.5
4.72	.302	.054	.006	T	3.1	161.6	None	356	100	9.85	3900	17.5
2.79	.202	.026	T	.04	4.1	229.2	8.6	302	63	9.75	1200	9.0
7.55	.358	.077	.009	.13	2.3	167.8	10.3	679	103	8.80	11975	.....
b. EAST FORK OF LITTLE MIAMI RIVER.												
6.72	.300	.044	.001	.03	2.1	154.8	39.0	270	89	8.00	3200	17.0
6.95	.372	.018	.006	.14	.5	160.8	42.0	258	100	......	....	.....
5.43	.296	.148	.002	.12	.5	149.4	23.4	257	83	6.30	750	26.0
5.54	.310	.118	.010	.04	T	167.6	None	251	76	6.30	2100	27.0
6.54	.332	.086	.012	T	None	80.0	None	307	52	6.58	39900	27.5
5.28	.398	.060	.003	None	1.1	135.4	50.2	238	39	7.05	2300	18.5
5.97	.268	.035	.003	None	2.2	111.4	10.2	251	76	10.90	5400	16.0
5.32	.330	.034	.002	.08	4.6	121.8	6.8	233	49	9.55	1500	9.0
5.97	.326	.068	.005	.05	1.4	135.1	21.4	258	71	7.81	7878	.....
6.44	.350	.052	.002	.02	2.4	157.6	63.8	299	98	7.90	3500	17.0
7.15	.348	.032	.007	.16	1.1	161.2	19.4	277	105	......	....	.....
5.47	.266	.146	.010	.13	.9	143.2	73.8	261	89	6.85	1300	26.0
5.28	.302	.136	.010	.03	.9	195.2	None	262	84	5.45	2200	27.0
6.87	.314	.104	.013	T	T	80.2	8.2	353	56	5.80	38400	28.0
5.08	.326	.102	.005	None	1.8	139.0	None	246	38	6.62	1500	19.5
6.60	.234	.020	.005	None	3.0	115.0	None	243	70	10.10	6000	16.0
4.37	.276	.034	.002	.04	4.4	124.4	23.2	230	65	9.65	2300	9.0
5.91	.313	.078	.007	.05	1.8	139.5	23.5	271	76	7.48	7886	.....

RECORD OF CHEMICAL AND BACTERIOLOGICAL EXAMINATIONS OF

GREAT MIAMI WATERSHED,

a STILLWATER BASIN.

Greenville Creek.

(Parts per

Sample number.	Serial number.	Approximate distances.	Locality of sample.	Date collected.	Color.	Turbidity.	Sediment.	Odor.
1047	8	126	Greenville, above town	April 17	.20	.08	S.	Faint veg've.
1112	33	....	“	May 22	.28	.07	S.	Vegetative.
1180	62	....	“	June 18	.25	.08	S.	“
1217	91	....	“	July 10	.27	.18	S.	“
1267	120	....	“	Aug. 7	.22	.17	C.	“
1331	149	....	“	Sept. 3	.23	.14	S.	“
1394	178	....	“	Oct. 1	.42	.30	C.	“
1468	206	....	“	Nov. 1	.20	.08	S.	Earthy.
			AVERAGE	....	.26	.14	......	....
1048	9	124	Greenville, below town	April 17	.25	.18	S.	Sour.
1113	34	....	“	May 22	.25	.11	S.	Vegetative.
1181	63	....	“	June 18	.23	.10	C.	“
1218	92	....	“	July 10	.23	.16	S.	Faint musty.
1268	121	....	“	Aug. 7	.23	.23	C.	Vegetative.
1332	150	....	“	Sept. 3	.21	.17	S.	Vegetative & faint musty.
1393	177	....	“	Oct. 1	.48	.38	C.	Vegetative.
1469	207	....	“	Nov. 1	.30	.08	S.	Earthy.
			AVERAGE	....	.27	.18	......	....
1054	13	79	Dayton, above town	April 18	.26	.40	C.	Earthy.
1119	38	....	“ “	May 23	.14	.08	S.	Faint veg've.
1177	67	....	“ “	June 19	.28	.15	C.	Faint sour.
1221	95	....	“ “	July 10	.25	.16	V. S.	Vegetative.
1272	125	....	“ “	Aug. 8	.25	.13	S.	“
1335	153	....	“ “	Sept. 4	.25	.25	S.	Sour.
1398	182	....	“ “	Oct. 2	.21	.19	S.	Faint veg've.
1475	211	....	“ “	Nov. 2	.24	.27	S.	“
			AVERAGE	....	.23	.20	......	....

GREAT AND LITTLE MIAMI RIVERS AND TRIBUTARIES — Continued.

GREAT MIAMI WATERSHED.

a STILLWATER BASIN.

Million.)

Greenville Creek.

Oxygen required.	Nitrogen as				Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen.	Bacteria per c. c.	Temperature °C.
	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.								
4.30	.188	.030	.016	3.44	.2	217.8	83.0	449	167	10.34	3300	12.5
4.41	.211	.094	.038	2.09	T	226.2	40.0	380	141	10.45	1100	22.0
4.25	.184	.084	.014	.55	.6	278.4	31.0	467	145	8.95	1300	25.0
5.17	.214	.060	.020	.44	.4	280.0	None	369	75	6.44	1100	20.0
5.15	.268	.134	.011	None	2.7	255.4	3.2	421	147	12.35	2000	31.0
3.77	.186	.096	.010	T	1.0	269.0	None	413	136	8.40	4700	26.0
6.76	.272	.063	.024	2.12	None	189.6	35.0	432	148	8.25	19000	19.0
3.13	.164	.019	.002	T	1.5	274.0	26.6	472	142	9.05	6400	15.5
4.62	.211	.072	.017	1.08	.8	248.8	27.3	425	138	9.28	4862	.....
5.68	.308	.088	.024	3.15	.8	214.2	74.4	474	158	9.54	22000	12.5
4.81	.292	.108	.038	2.35	1.0	235.8	55.2	422	150	10.01	3000	22.0
4.86	.226	.104	.018	.54	2.0	268.4	55.0	535	192	8.83	10400	25.0
5.13	.196	.070	.019	.72	3.0	285.2	8.2	415	102	6.60	2800	20.0
5 15	.227	.102	.022	.16	5.0	270.6	None	483	169	9.60	7600	30.0
4.51	.340	.106	.024	.05	3.9	265.0	9.4	484	160	8.57	7400	26.5
7.43	.394	.094	.020	2.38	1.0	194.6	3.84	521	156	8.00	15000	19.5
4.41	.210	.058	.009	None	3.9	280.0	42.6	464	145	9.90	38000	15.5
5.25	.274	.091	.022	1.17	2.6	251.7	35.4	475	154	8.88	13275	.....
5.93	.284	.020	.015	3.78	.4	187.8	24.0	478	151	8.78	24300	14.0
3.62	.242	.058	.006	.82	1.1	218.2	None	348	122	8.30	1000	21.5
3.94	.182	.030	.010	2.33	1.0	244.0	21.0	434	158	8.83	1300	24.0
5.77	.288	.040	.003	.97	.1	229.2	13.2	361	123	8.80	2100	26.5
3.76	.226	.038	.006	None	.8	223.2	3.2	342	95	7.90	1200	30.0
4.58	.280	.086	.022	.59	.3	221.4	5.2	376	137	8.57	2300	28.0
4.24	.275	.031	T	.03	2.3	231.4	None	381	141	9.70	330000§	21.5
4.20	.234	.024	.014	7.66	1.3	196.0	None	317	103	8.95	3100	15.5
4.50	.251	.041	.009	2.02	.9	218.9	8.3	380	129	8.73	45662	.....

§ Chiefly one species.

RECORD OF CHEMICAL AND BACTERIOLOGICAL EXAMINATIONS, OF

b MAD RIVER BASIN.

Buck Creek.

(Parts per

Sample number.	Serial number.	Approximate distances.	Locality of sample.	Date collected.	Color.	Turbidity.	Sediment.	Odor.
1040	1	103	Springfield, above town	April 16	.10	.05*	S.	None.
1124	45	....	"	May 24	.10	.10	C.†	Vegetative.
1187	72	....	"	June 20	.23	.09	S.	Faint earthy.
1225	99	....	"	July 10	.15	.23	C.	"
1281	132	....	"	Aug. 9	.17	.14	S.	Vegetative.
1343	161	....	"	Sept. 5	.13	.16	S.	"
1406	189	....	"	Oct. 3	.15	.10	S.	Faint veg've.
1484	216	....	"	Nov. 3	.17	.05	V. S.	None.
			AVERAGE	....	.15	.11	......	....
			Mad River.					
1057	16	114	Urbana, above town	April 19	.32	.25	C.	Earthy.
1120	41	....	" "	May 24	.12	.05	S.	Faint earthy.
1184	71	....	" "	June 20	.21	.18	C.	Faint veg've.
1214	88	....	" "	July 9	.18	.25	S.	"
1276	128	....	" "	Aug. 9	.22	.24	S.	Vegetative.
1340	158	....	" "	Sept. 5	.28	.38	C.	Earthy, veg.
1402	185	....	" "	Oct. 3	.18	.23	S.	Vegetative.
1482	217	....	" "	Nov. 3	.20	.08	V. S.	None.
			AVERAGE	....	.21	.21	......	....
1058	17	112	Urbana, below town	April 19	.35	25	C.	Strong.
1121	12	....	" "	May 21	.58	.19	C.	Strawboard.
1183	70	....	" "	June 20	.60	.35	C.	"
1213	87	....	" "	July 9	.22	.30	C.	Vegetative.
1277	129	....	" "	Aug. 9	.52	.20	C.	Foul.
1339	157	....	" "	Sept. 5	.55	.42	C.	Strawboard.
1403	186	....	" "	Oct. 3	.55	.27	C.	"
1483	218	....	" "	Nov. 3	.40	.25	M.	"
			AVERAGE	....	47	.28	......	....
1041	2	100	Springfield, above town	April 16	.20	.07	S.	Earthy.
1123	44	....	"	May 24	.27	.12	C.	Vegetative.
1188	73	....	"	June 20	.25	.20	C.	Earthy.
1223	97	....	"	July 10	.22	.30	S.	Sweet, veget.
1279	131	....	"	Aug. 9	.35	.19	C.	Vegetative.
1341	159	....	"	Sept. 5	.23	.36	C.	"
1405	188	....	"	Oct. 3	.29	.27	C.	"
1481	215	....	"	Nov. 3	.38	.15	C.	"
			AVERAGE	....	.27	.21	......	... .

† Floating vegetation which had settled to bottom.

GREAT AND LITTLE MIAMI RIVERS AND TRIBUTARIES — Continued.

b MAD RIVER BASIN.

Million.)

Buck Creek.

Oxygen required.	Nitrogen as				Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen.	Bacteria per c. c.	Temperature °C.
	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.								
1.67	.104	.016	.005	.84	.4	242.0	2.98	407	124	9.83	325	13.0
2.48	.328	.032	.010	1.14	.3	244.4	27.2	431	135	9.70	1200	20.5
2.26	.096	.036	.008	.83	.2	268.0	12.0	438	135	9.10	375	25.0
4.01	.176	.028	.010	1.06	.4	260.2	30.0	463	145	7.79	800	25.0
2.63	.134	.042	.010	1.64	T	227.6	29.0	384	115	9.35	400	30.5
2.77	.206	.044	.011	1.46	T	239.4	1.8	386	123	9.68	600	27.0
1.99	.112	.022	.002	1.63	.4	219.4	3.0	425	150	9.90	1200	24.0
1.65	.078	.019	.014	2.12	.5	249.4	13.2	399	82	10.30	1000	8.5
2.43	.154	.030	.009	1.34	.3	243.8	18.2	417	126	9.46	738	.....
						Mad River.						
6.90	.258	.014	.010	1.87	T	229.0	60.6	497	167	9.67	12000	13.0
9.82	.104	.040	.010	.82	.5	265.4	3.0	347	92	7.92	700	17.5
3.52	.170	.050	.009	.83	T	271.8	26.8	434	131	8.73	1700	19.5
4.22	.220	.060	.017	.64	.2	266.2	11.4	410	76	9.00	2200	20.5
3.95	.182	.054	.016	1.04	.2	250.4	None	396	103	7.60	3300	24.5
5.53	.380	.032	.007	.83	T	230.4	21.0	438	127	8.86	5900	20.5
3.24	.130	.032	.006	1.26	1.0	260.2	1.6	462	173	8.70	4000	18.0
2.53	.086	.019	.005	T	T	251.4	1.4	390	112	11.05	2200	10.5
4.96	.191	.038	.010	.91	.2	253.1	14.5	422	123	8.94	4000	.....
14.50	.400	.026	.024	2.80	.4	225.0	43.4	466	156	9.40	39500	14.5
66.96	.602	.028	.144	T	.7	285.2	24.0	396	147	6.60	63600	17.5
25.46	.540	.014	.044	None	.2	305.6	36.2	485	163	5.86	109000	18.0
7.85	.360	.052	.028	.62	.6	282.8	17.0	399	105	6.50	6800	19.5
61.64	.564	.024	.076	T	6.4	284.6	11.6	463	155	6.03	17500	24.0
27.98	.910	.028	.112	.16	.3	266.6	None	481	167	5.85	111000	20.0
21.00	.780	.060	.010	.06	.6	283.8	None	493	180	6.10	803000	18.0
28.96	.712	.080	.044	.13	.5	295.8	None	462	149	6.70	135600	11.0
31.79	.608	.039	.060	.47	1.2	278.7	16.5	456	153	6.63	160750	.....
3.26	.120	.030	.016	1.06	.5	261.0	11.8	412	142	9.60	3300	12.0
8.34	.268	.022	.062	.08	.2	276.2	5.6	426	126	7.74	30000	19.0
3.98	.187	.176	.018	.44	.7	278.6	40.4	423	129	7.98	7400	23.5
5.40	.226	.132	.026	1.04	.9	268.2	None	462	153	7.50	3200	24.0
7.15	.334	.048	.007	None	.4	288.2	None	430	134	8.00	1400	28.0
4.68	.366	.136	.032	1.11	.8	248.4	39.0	430	143	8.43	2700	23.5
7.56	.276	.036	.018	.08	.2	274.8	None	456	167	7.57	7800	20.0
11.49	.306	.024	.048	.04	.5	281.4	None	410	134	9.05	20800	10.0
6.48	.260	.076	.028	.48	.5	272.1	12.1	431	141	8.23	9575	.....

RECORD OF CHEMICAL AND BACTERIOLOGICAL EXAMINATIONS OF

Mad River — Concluded. **(Parts per**

Sample number.	Serial number.	Approximate distances.	Locality of sample.	Date collected.	Color.	Turbidity.	Sediment.	Odor.
1042	3	99	Springfield, below town	April 16	.20	.07	S.	Faint musty.
1122	43	....	"	May 24	.27	.13	C.	Musty.
1189	74	....	"	June 20	.25	.24	C.	Faint musty.
1224	98	....	"	July 10	.20	.24	C.	"
1278	130	....	"	Aug. 9	.28	.17	C.	Musty.
1342	160	....	"	Sept. 5	.21	.32	S.	Vegetative.
1404	187	....	"	Oct. 3	.21	.21	C.	Faint musty.
1480	214	....	"	Nov. 3	.32	.13	C.	"
			AVERAGE	....	.24	.19	......	....
1059	11	80	Dayton, above town	April 18	.20	.28	C.	Earthy.
1117	36	....	" "	May 23	.12	.13	S.	"
1175	65	....	" "	June 19	.22	.27	C.	Faint earthy.
1219	93	....	" "	July 10	.20	.14	V. S.	Faint sour.
1270	123	....	" "	Aug. 8	.20	.23	S.	Earthy.
1333	151	....	" "	Sept. 4	.23	.23	C.	Vegetative.
1396	180	....	" "	Oct. 2	.23	.19	S.	Earthy.
1473	209	....	" "	Nov. 2	.19	.16	S.	"
			AVERAGE	....	.20	.20	......	....

C GREAT MIAMI BASIN.

Great Miami River.

Sample number.	Serial number.	Approximate distances.	Locality of sample.	Date collected.	Color.	Turbidity.	Sediment.	Odor.
1046	7	124	Sidney, above town	April 17	.20	.11	S.	Vegetative.
1111	32	....	" "	May 22	.20	.16	S.	"
1179	61	....	" "	June 18	.22	.15	S.	"
1216	90	....	" "	July 9	.22	.20	S.	"
1266	119	....	" "	Aug. 7	.30	.12	S.	"
1330	148	....	" "	Sept. 3	.26	.22	S.	"
1392	174	....	" "	Oct. 1	.24	.14	S.	Faint veg've.
1471	205	....	" "	Nov. 1	.22	.22	S.	Vegetative.
			AVERAGE	....	.23	.16	......	....
1045	6	122	Sidney, below town	April 17	.20	.11	S.	Vegetative.
1110	31	....	" "	May 22	.22	.09*	S.	"
1178	60	....	" "	June 18	.28	.10*	S.	"
1215	89	....	" "	July 9	.20	.14	S.	"
1265	118	....	" "	Aug. 7	.30	.09*	S.	"
1329	147	....	" "	Sept. 3	.27	.15	S.	"
1391	173	....	" "	Oct. 1	.25	.17	S.	"
1470	204	....	" "	Nov. 1	.20	.13	S.	"
			AVERAGE	....	.24	.12	......	....

GREAT AND LITTLE MIAMI RIVERS AND TRIBUTARIES — Continued.

Million.)

Mad River — Concluded.

Oxygen required.	Nitrogen as				Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen.	Bacteria per c. c.	Temperature °C.
	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.								
2.69	.170	.144	.032	1.52	1.7	256.2	22.2	427	126	9.30	7600	12.0
14.08	.276	.262	.084	.26	2.4	274.8	25.2	404	128	7.25	43800	19.0
4.19	.226	.152	.036	.58	3.6	279.6	3.2	484	159	7.70	18300	24.0
4.52	.210	.202	.044	.85	3.5	267.2	13.8	459	153	7.38	10000	25.0
5.37	.320	.302	.028	.27	4.5	273.4	None	405	130	8.01	5900	28.0
4.05	.296	.172	.038	1.28	4.5	260.0	9.4	427	151	8.72	115100	24.0
5.41	.346	.110	.022	.04	3.1	272.2	None	473	164	7.22	29700	20.5
7.25	.314	.266	.052	.04	3.3	281.4	None	401	141	8.07	14600	10.0
5.94	.270	.201	.042	.60	3.3	270.6	9.2	435	144	7.96	30625	.....
5.19	.272	.076	.030	2.05	1.5	241.6	12.8	535	150	9.00	30900	14.0
3.08	.148	.034	.016	.78	3.0	259.8	32.2	368	99	8.77	1500	19.0
3.85	.163	.016	.012	.39	3.1	266.0	37.0	460	183	8.55	2700	21.0
3.34	.202	.018	.005	.60	4.0	259.2	None	408	53	9.32	3300	24.0
3.41	.156	.039	.007	.67	2.5	243.2	None	425	161	9.00	1700	26.5
4.34	.227	.033	.008	.91	2.6	257.8	None	451	123	8.96	5800	13.5
4.77	.217	.029	.002	.77	2.9	250.2	None	406	125	8.95	5600	19.5
2.97	.170	.020	.012	4.42	2.7	261.0	2.98	385	111	9.03	2500	13.0
3.87	.194	.033	.011	1.32	2.8	254.8	14.0	417	126	8.95	6750	.....

C GREAT MIAMI BASIN.

Great Miami River.

Oxygen required.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen.	Bacteria per c. c.	Temperature °C.
4.77	.194	.024	.010	3.59	.4	194.2	52.8	408	147	8.99	1700	11.0
4.20	.326	.070	.010	.35	1.7	230.2	33.0	381	124	10.70	450	23.5
4.80	.226	.104	.010	None	.4	237.0	35.0	414	109	10.90	800	27.0
8.11	.330	.048	.010	.19	1.6	221.2	68.4	457	125	9.63	1000	27.0
5.57	.270	.074	.008	None	.4	212.2	1.0	350	130	11.72	650	31.0
6.04	.360	.100	.022	.03	.2	220.4	56.0	406	117	8.60	750	27.0
5.11	.258	.048	.003	None	.4	221.0	None	393	129	8.82	6600	21.0
6.28	.398	.057	.002	T	.6	222.0	20.4	422	117	9.97	3300	17.0
5.61	.295	.066	.009	.52	.7	219.8	33.3	404	125	9.92	1906	.....
4.65	.246	.038	.016	3.02	.6	205.8	42.0	430	156	10.03	6100	11.0
3.88	.388	.080	.018	.58	2.6	226.8	13.0	345	120	12.00	1600	24.0
4.23	.226	.112	.016	.08	3.8	252.6	54.0	402	135	9.23	1600	26.5
6.19	.256	.052	.014	.56	2.7	231.2	30.4	360	81	9.30	2700	27.0
5.77	.254	.098	.018	None	3.4	219.8	5.4	352	128	10.70	2900	31.0
5.87	.364	.094	.016	.32	1.9	223.6	25.8	374	131	10.92	5700	27.0
5.77	.316	.056	.004	None	.9	199.0	None	364	120	9.53	6600	20.5
6.25	.315	.063	.008	T	2.5	232.6	36.8	409	121	10.94	10800	17.0
5.33	.289	.074	.014	.57	2.3	223.9	25.9	379	124	10.33	4750	.....

RECORD OF CHEMICAL AND BACTERIOLOGICAL EXAMINATIONS OF

Great Miami River — Continued.

(Parts pe

Sample number.	Serial number.	Approximate distances.	Locality of sample.	Date collected.	Color.	Turbidity.	Sediment.	Odor.
1049	14	111	Piqua, above town.	April 18	.35	3.00	M.	Earthy.
1108	29	....	" "	May 22	.30	.17	C.	Vegetative.
1172	58	....	" "	June 18	.25	.33	C.	Earthy.
1228	103	....	" "	July 11	.27	.15	S.	Vegetative.
1263	116	....	" "	Aug. 7	.25	.12	S.	Faint musty.
1325	145	....	" "	Sept. 3	.25	.18	S.	Vegetative.
1389	175	....	" "	Oct. 1	.30	.40	C.	"
1466	202	....	" "	Nov. 1	.28	.26	S.	Earthy.
			AVERAGE	....	.28	.58	......	....
1050	15	108	Piqua, below town.	April 18	.22	2.70	M.	Earthy.
1109	30	....	" "	May 22	.30	.11*	S.	Faint musty.
1173	59	....	" "	June 18	.27	.26	C.	Faint musty and earthy.
1227	102	....	" "	July 11	.28	.14	S.	Sour.
1264	117	....	" "	Aug. 7	.28	.17*	S.	Musty.
1326	146	....	" "	Sept. 3	.26	.15*	S.	Veget've and faint musty.
1390	176	....	" "	Oct. 1	.30	.30	C.	Musty.
1467	203	....	" "	Nov. 1	.24	.24	S.	Faint musty.
			AVERAGE	....	.27	.51	......	....
1043	4	103	Troy, above town.	April 17	.20	.12	S.	Faint sour.
1115	40	....	" "	May 23	.20	.08	S.	Faint musty.
1186	69	....	" "	June 19	.27	.13	S.	"
1230	101	....	" "	July 11	.30	.18	S.	Musty.
1274	127	....	" "	Aug. 8	.34	.10	S.	Faint musty.
1338	156	....	" "	Sept. 4	.28	.15	S.	"
1401	184	....	" "	Oct. 2	.27	.15	S.	"
1477	213	....	" "	Nov. 2	.25	.21	S.	"
			AVERAGE	....	.26	.14	......	....
1044	5	100	Troy, below town.	April 17	.18	.14	S.	Faint sour.
1114	39	....	" "	May 23	.16	.08*	S.	" musty.
1185	68	....	" "	June 19	.27	.06	S.	Musty.
1229	100	....	" "	July 11	.28	.12	S.	Faint musty.
1273	126	....	" "	Aug. 8	.20	.06	S.	"
1337	155	....	" "	Sept. 4	.29	.11	S.	"
1400	183	....	" "	Oct. 2	.25	.08	V. S.	"
1476	212	....	" "	Nov. 2	.26	.13	S.	"
			AVERAGE	....	.24	.10	......	....

GREAT AND LITTLE MIAMI RIVERS AND TRIBUTARIES — Continued.

Million.)

Great Miami River — Continued.

Oxygen required.	Nitrogen as				Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen.	Bacteria per c. c.	Temperature °C.
	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.								
25.87	1.012	.062	.008	4.40	T	118.6	38.8	1123	189	9.40	57000	15.0
4.26	.348	.094	.016	.33	1.9	225.8	41.8	367	129	9.08	1400	20.0
5.18	.266	.066	.018	.18	.8	239.0	50.0	463	152	7.29	3700	23.0
6.18	.332	.056	.006	T	1.4	219.2	32.4	426	159	9.83	2900	26.0
5.32	.256	.086	.012	None	1.6	205.2	15.2	370	136	6.85	4400	27.0
5.42	.330	.110	.012	.27	.6	206.4	29.0	355	114	5.60	4100	25.5
5.96	.272	.058	.003	None	.7	170.2	8.8	353	116	8.40	7100	21.0
6.42	.386	.086	.004	T	2.2	220.2	39.0	414	116	8.30	8000	17.0
8.08	.400	.077	.010	.65	1.2	200.6	31.9	484	139	8.09	11075	.....
17.02	.794	.044	.009	4.95	T	137.4	19.0	853	156	9.15	61700	15.0
4.44	.356	.114	.032	.74	4.1	228.2	31.8	364	130	9.56	9000	21.0
5.35	.294	.116	.022	.32	1.6	241.0	36.0	493	189	8.05	12100	24.5
6.24	.340	.062	.034	.49	4.8	226.2	47.4	499	184	8.23	14300	26.0
5.44	.210	.086	.040	None	5.1	223.8	22.0	384	144	7.69	14800	28.0
5.81	.292	.130	.032	.67	4.8	216.0	15.8	387	127	7.41	8900	25.0
6.72	.300	.042	.012	T	2.5	178.2	3.2	371	134	8.06	21300	21.5
6.36	.408	.077	.032	None	4.0	220.4	25.0	394	126	8.26	39000	17.0
7.17	.374	.084	.027	.90	3.4	208.9	25.0	468	149	8.30	22638	.....
4.39	.260	.348	.032	2.62	1.9	187.0	53.8	407	161	8.03	10600	11.0
5.97	.402	.098	.016	.22	2.6	228.0	17.0	352	92	9.06	3000	23.0
5.34	.275	.080	.016	.47	1.6	237.2	55.0	423	144	8.99	6300	25.0
6.66	.368	.044	.022	.45	2.5	222.4	47.4	465	174	6.38	5100	24.0
6.75	.288	.106	.008	T	2.3	215.8	4.2	337	106	8.90	5900	30.0
6.54	.488	.102	.026	.54	2.5	207.4	10.2	377	131	7.05	2800	26.5
6.59	.332	.034	.010	.03	2.3	195.4	22.8	353	139	6.69	6500	21.5
6.99	.336	.029	.018	T	3.4	224.4	7.4	389	122	7.55	4800	15.0
6.15	.344	.105	.018	.54	2.4	214.7	27.2	388	134	7.83	5625	.....
4.33	.222	.064	.024	3.42	1.4	184.8	56.6	379	127	7.82	6400	11.0
4.85	.418	.212	.022	.45	5.0	240.4	40.0	347	95	10.26	4800	23.0
5.69	.282	.180	.030	.11	2.6	247.8	17.6	383	120	10.00	109500	25.0
5.81	.372	.076	.028	.37	3.7	231.2	13.0	438	170	7.25	8600	24.0
4.83	.276	.120	.010	.22	3.0	224.8	None	312	107	10.41	4000	29.5
5.88	.534	.126	.018	.34	2.8	213.2	29.2	342	130	9.87	5600	26.5
5.88	.338	.084	.014	T	3.4	210.4	None	338	130	8.50	45600	21.5
7.41	.586	.038	.003	T	3.4	222.6	7.0	377	115	6.05	228000	15.0
5.58	.378	.112	.019	.61	3.2	221.9	20.4	364	124	8.77	51562	.....

RECORD OF CHEMICAL AND BACTERIOLOGICAL EXAMINATIONS OF

Great Miami River — Continued.

(Parts per

Sample number.	Serial number.	Approximate distances.	Locality of sample.	Date collected.	Color.	Turbidity.	Sediment.	Odor.
1053	12	80	Dayton, above town	April 18	.25	.21	C.	Earthy.
1118	37	....	“ “	May 23	.22	.19	S.	Faint musty.
1176	66	....	“ “	June 19	.30	.30	C.	Vegetative.
1220	94	....	“ “	July 10	.25	.19	S.	Veg., earthy.
1271	124	....	“ “	Aug. 8	.26	.20	S.	Earthy.
1334	152	....	“ “	Sept. 4	.30	.33	C.	Vegetative.
1397	181	....	“ “	Oct. 2	.21	.26	C.	Faint musty.
1474	210	....	“ “	Nov. 2	.19	.29	S.	Earthy.
			AVERAGE	....	.25	.25	......	....
1052	10	75	Dayton, below town	April 18	.28	.60	C.	Faint musty.
1116	35	....	“ “	May 23	.26	.13	C.	“
1174	64	....	“ “	June 19	.23	.11	C.	Earthy.
1222	96	....	“ “	July 10	.25	.15	S.	Musty.
1269	122	....	“ “	Aug. 8	.24	.16	S.	“
1336	154	....	“ “	Sept. 4	.26	.20	S.	Musty, oily.
1395	179	....	“ “	Oct. 2	.25	.16	S.	Musty.
1472	208	....	“ “	Nov. 2	.22	.18	S.	Faint musty.
			AVERAGE	....	.25	.21	......	....
1075	26	49	Middletown, above town	April 26	.22	.09	C.	Strong veg.
1129	49	....	“	May 28	.31	.14	S.	Vegetative.
1205	83	....	“	June 28	.35	1.90	M.	“
1242	108	....	“	July 19	.26	.57	C.	Faint musty.
1306	141	....	“	Aug. 22	.26	.67	C.	Earthy, veg.
1366	172	....	“	Sept. 19	.18	.13	V. S.	Vegetative.
1429	190	....	“	Oct. 13	.38	.35	C.	“
1486	220	....	“	Nov. 7	.23	.12	S.	“
			AVERAGE	....	.27	.50	......	....
1074	25	47	Middletown, below town	April 26	.24	.21	C.	Vegetative.
1130	50	....	“	May 28	.31	.16	S.	Faint musty.
1206	84	....	“	June 28	.35	1.80	M.	Oily.
1243	109	....	“	July 19	.26	.54	C.	Musty.
1307	142	....	“	Aug. 22	.30	.73	C.	Earthy.
1365	171	....	“	Sept. 19	.28	.30	S.	Veg., ft. must.
1430	191	....	“	Oct. 13	.33	.31	C.	Musty.
1487	221	....	“	Nov. 7	.25	.23	S.	“
			AVERAGE	....	.29	.53	......	....

GREAT AND LITTLE MIAMI RIVERS AND TRIBUTARIES — Continued.

Million.)

Great Miami River — Continued.

Oxygen required.	Nitrogen as				Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen.	Bacteria per c. c.	Temperature °C.
	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.								
5.92	.248	.022	.020	3.74	.6	189.2	10.2	448	159	8.83	17600	13.5
5.94	.384	.084	.018	1.02	1.4	239.6	44.2	366	123	7.35	2700	21.0
5.61	.282	.044	.024	.47	1.8	237.0	23.0	445	188	9.90	4800	23.0
6.02	.312	.034	.014	.20	1.8	224.4	70.8	442	117	7.35	4700	24.5
5.24	.276	.073	.006	None	1.2	219.4	30.6	368	132	6.78	2900	28.5
6.99	.400	.074	.008	T	1.0	222.0	None	388	119	7.22	3500	26.0
5.30	.252	.028	.004	.04	2.3	224.0	None	403	158	7.40	5600	20.0
6.16	.304	.034	.013	T	1.8	212.0	20.2	400	105	7.30	3000	15.5
5.90	.307	.049	.013	.68	1.5	220.9	24.9	407	138	7.52	5600	.....
7.82	.396	.032	.020	3.36	.8	193.4	67.2	591	156	9.00	118600	13.0
4.52	.412	.102	.034	1.10	3.9	240.2	8.2	351	95	6.96	9700	18.5
4.27	.230	.084	.016	.40	4.7	245.0	47.0	436	200	6.70	22300	21.0
6.14	.264	.056	.030	1.16	5.5	237.2	4.0	352	103	8.30	150000	27.0
5.57	.284	.062	.018	.34	4.4	230.2	None	400	160	5.83	41400	26.5
5.18	.356	.066	.024	.68	3.9	225.6	33.0	398	150	9.22	8100	28.0
5.87	.259	.056	.008	.04	3.8	223.8	15.0	349	128	7.05	100900	19.5
4.31	.274	.076	.020	8.80	6.9	227.0	14.0	380	123	7.70	72900	13.5
5.46	.309	.067	.021	1.99	4.2	227.8	23.5	407	139	7.59	65487	.....
4.08	.216	.022	.018	2.60	1.6	204.2	6.0	373	152	10.07	4900	16.0
6.29	.224	.032	.032	.57	4.4	237.0	None	406	131	8.95	14100	21.5
10.11	.432	.084	.010	.12	.6	194.8	12.4	556	131	6.68	54900	26.0
9.32	.274	.054	.020	.32	4.0	211.0	54.6	453	140	7.16	21600	27.0
7.72	.278	.070	.013	T	2.4	204.8	40.8	403	144	6.39	40000	26.0
6.92	.232	.016	.008	T	6.1	230.2	18.0	422	102	9.82	9200	21.0
8.34	.253	.074	.014	None	3.3	189.0	None	410	134	8.45	2400	15.0
5.21	.176	.012	.008	.05	4.1	226.4	16.0	363	109	11.70	4000	12.5
7.25	.261	.045	.015	.46	3.3	212.2	18.5	423	130	8.65	18888	.....
4.70	.286	.034	.024	3.32	2.3	202.4	2.2	370	134	8.70	13000	16.0
7.91	.326	.058	.038	.49	4.5	232.4	20.0	460	151	7.16	27500	21.5
12.16	.464	.048	.012	.14	1.9	198.0	4.0	593	133	6.27	124100	25.5
11.11	.280	.074	.024	.08	7.3	222.0	39.8	484	173	5.90	36900	27.0
10.78	.332	.068	.015	T	4.2	240.8	17.8	446	153	5.67	97100	27.5
9.89	.438	.046	.020	None	9.3	239.8	None	463	131	8.09	33700	21.0
7.97	.273	.032	.016	T	5.1	186.8	27.6	434	156	7.45	2800	15.0
9.65	.318	.016	.026	.06	7.8	242.2	12.2	435	153	7.50	8800	13.5
9.27	.340	.047	.022	.51	5.3	220.5	15.4	461	148	7.09	42987	.....

RECORD OF CHEMICAL AND BACTERIOLOGICAL EXAMINATIONS OF

Great Miami River — Concluded.

(Parts per

Sample number.	Serial number.	Approximate distances.	Locality of sample.	Date collected.	Color.	Turbidity.	Sediment.	Odor.
1070	24	35	Hamilton, above town	April 25	.16	.09	C.	Vegetative.
1132	51	....	"	May 28	.28	5.60	M.	Earthy.
1207	81	....	"	June 27	.27	2.80	M.	Vegetative.
1240	110	....	"	July 19	.28	2.45	M.	Earthy.
1309	140	....	"	Aug. 21	.28	.93	C.	"
1372	170	....	"	Sept. 19	.25	.25	S.	Vegetative.
1427	192	....	"	Oct. 13	.43	.43	C.	Faint musty.
1488	222	....	"	Nov. 7	.25	.25	S.	"
			AVERAGE	....	.28	1.60	......	....
1069	23	32	Hamilton, below town	April 25	.18	.09	C.	Musty.
1133	52	....	"	May 28	.28	5.40	M.	Earthy.
1208	82	....	"	June 27	.27	1.80	M.	Oily.
1241	111	....	"	July 19	.26	1.40	M.	Earthy.
1308	139	....	"	Aug. 21	.28	.75	C.	"
1371	169	....	"	Sept. 19	.25	.23	S.	Faint musty.
1428	193	....	"	Oct. 13	.33	.44	C.	"
1489	223	....	"	Nov. 7	.27	.20	S.	Musty.
			AVERAGE	....	.26	1.29	......	....
1067	22	5	Cleves, below town	April 25	.16	.11	C.	Vegetative.
1135	53	....	" "	May 29	.23	5.20	M.	Earthy and ft. musty.
1201	80	....	" "	June 27	.30	2.00	M.	Earthy and ft. musty.
1247	115	....	" "	July 20	.30	5.40	M.	Veg., earthy.
1298	138	....	" "	Aug. 21	.28	.93	C.	Earthy.
1361	165	....	" "	Sept. 18	.20	.34	S.	"
1431	194	....	" "	Oct. 13	.31	.38	C.	Earthy, veg.
1497	227	....	" "	Nov. 8	.27	.24	S.	Earthy.
			AVERAGE	....	.26	1.82	......	....

GREAT AND LITTLE MIAMI RIVERS AND TRIBUTARIES — Concluded.

Million.)

Great Miami River — Concluded.

Oxygen required.	Nitrogen as				Chlorine.	Alkalinity.	Incrusting constituents.	Total solids.	Loss on ignition.	Dissolved oxygen.	Bacteria per c. c.	Temperature °C.
	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.								
3.04	.160	.030	.022	3.02	1.8	201.2	3.8	316	128	9.65	6100	18.5
26.89	.736	.076	.009	1.83	.1	122.4	7.4	1794	171	8.47	84500	19.5
12.78	.372	.082	.014	.98	1.1	186.4	None	621	115	7.02	53600	26.0
10.95	.374	.065	.012	.08	2.1	180.2	22.2	592	119	7.10	16700	28.0
7.24	.320	.096	.016	T	3.6	187.2	21.0	436	118	7.48	13600	29.0
7.01	.288	.031	.009	.07	7.1	226.0	8.2	416	106	9.68	1100	20.5
7.75	.268	.065	.008	T	3.6	179.4	29.2	418	134	8.56	2200	15.5
7.26	.246	.018	.007	T	5.5	227.2	19.6	417	125	9.78	25000	12.5
10.36	.345	.058	.012	.75	3.1	188.7	13.9	626	127	8.47	25350	.....
4.27	.254	.058	.030	2.60	3.3	206.8	15.8	347	137	9.02	8200	19.0
22.15	.788	.085	.012	1.36	2.1	140.4	2.8	1547	161	7.88	57600	19.5
9.32	.302	.072	.022	.34	3.9	230.0	35.6	467	122	6.78	78600	26.5
10.28	.342	.066	.016	.14	4.0	195.8	30.0	500	133	6.90	20400	28.0
7.69	.290	.078	.013	T	3.8	182.8	7.2	383	132	6.82	53800	29.0
7.50	.346	.122	.024	.06	9.7	230.6	12.6	414	111	7.70	3200	20.5
7.80	.263	.073	.010	T	4.4	181.2	None	371	122	8.40	7200	15.5
7.80	.304	.023	.018	.06	6.7	227.6	11.8	381	128	9.15	38200	12.0
9.60	.361	.072	.018	.57	4.7	199.4	14.5	551	131	7.83	33400	.....
4.27	.204	.032	.020	3.01	2.2	203.4	7.6	369	141	9.20	2400	18.5
19.43	.696	.100	.014	.77	.7	121.4	15.2	1721	188	7.93	7200	19.0
10.66	.510	.086	.012	.59	4.3	225.6	28.0	674	130	7.62	4400	27.0
22.82	.708	.082	.018	.08	2.2	165.0	28.8	2066	224	6.60	14500	27.0
7.26	.310	.061	.010	.04	3.6	172.2	.6	430	118	7.72	17200	30.0
5.50	.278	.029	.008	.12	7.2	232.4	11.4	450	98	9.32	2300	19.0
7.27	.282	.046	.006	3.3	4.6	187.4	None	412	121	9.40	2900	17.0
6.68	.258	.012	.008	.08	6.5	226.6	7.8	381	129	10.20	5400	9.0
10.49	.406	.056	.012	.63	3.9	191.7	12.4	813	144	8.50	7038	.....

VII. LIST OF PLATES.

In plotting the analytical findings of the Great Miami River it was found advisable to plot the main stream on one page and the two main tributaries on a second page. For convenience in plotting curve "B" (Mad River) the station above Dayton is placed 10 miles nearer Springfield than it should be, but the omission of that distance is indicated on the plates.

There are three series of plates including four sets of curves and a total of thirty-three plates as follows:

SERIES 1.

Curve "A" Little Miami River and East Fork of Little Miami River.
Plate 1. Oxygen Required.
" 2. Nitrogen as Albuminoid Ammonia.
" 3. Nitrogen as Free Ammonia.
" 4. Nitrogen as Nitrites.
" 5. Nitrogen as Nitrates.
" 6. Chlorine.
" 7. Alkalinity.
" 8. Incrusting Constituents.
" 9. Total Solids.
" 10. Dissolved Oxygen.
" 11. Bacteria.

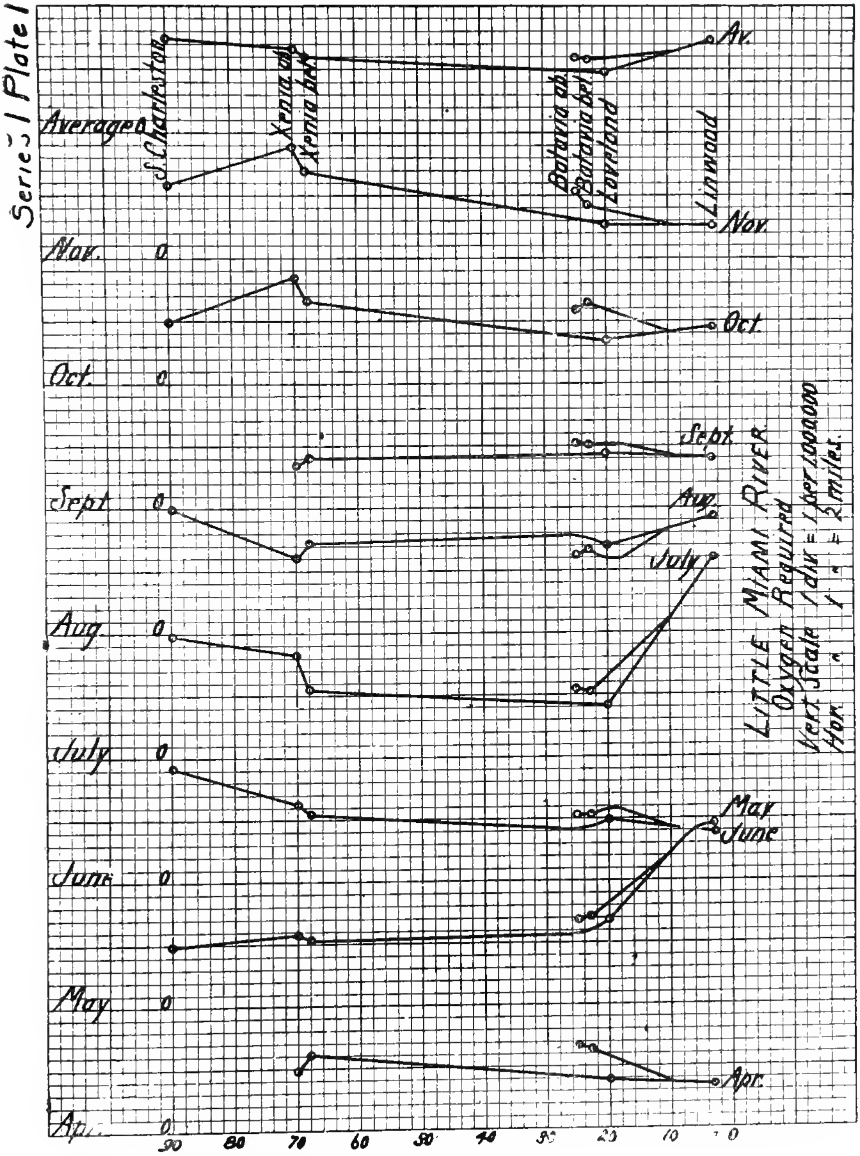
SERIES 2.

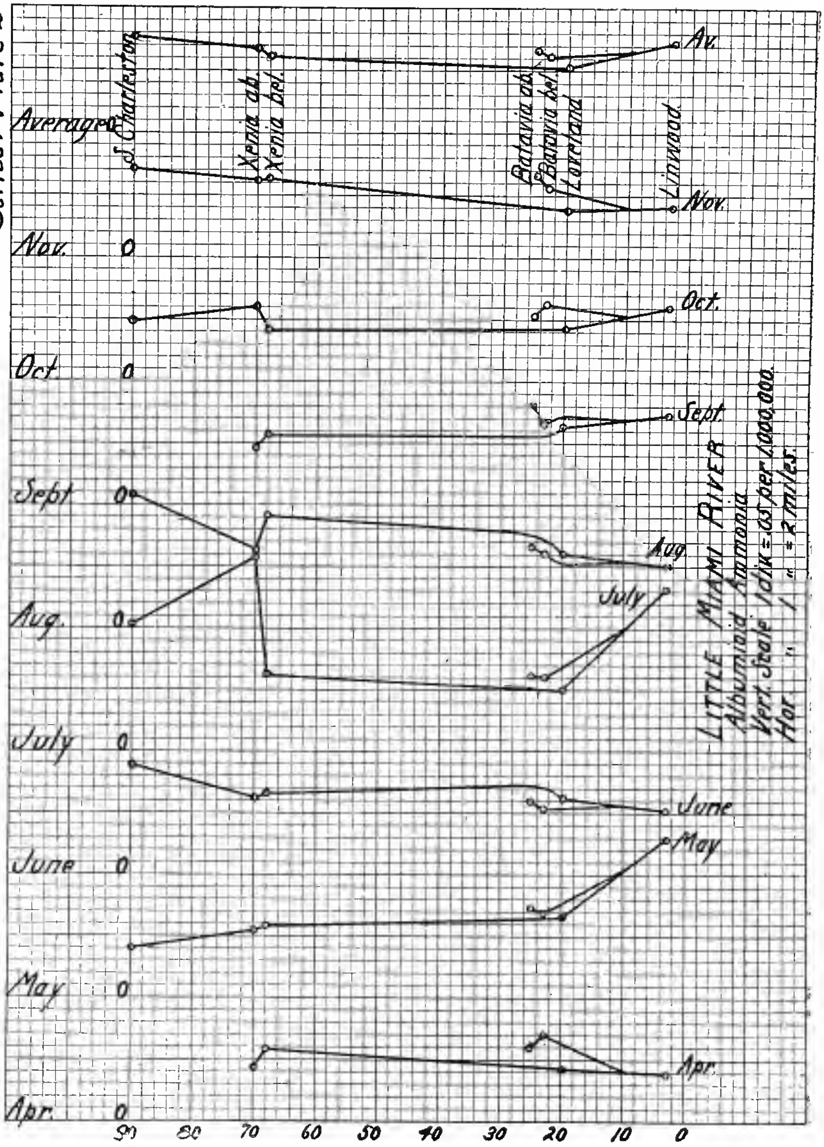
Curves "B" and "C".
Curve "B" Mad River and Buck Creek.
Curve "C" Stillwater River and Greenville Creek.
Plate 12. Oxygen Required.
" 13. Nitrogen as Albuminoid Ammonia
" 14. Nitrogen as Free Ammonia.
" 15. Nitrogen as Nitrites.
" 16. Nitrogen as Nitrates.
" 17. Chlorine.
" 18. Alkalinity.
" 19. Incrusting Constituents.
" 20. Total Solids.
" 21. Dissolved Oxygen.
" 22. Bacteria.

SERIES 3.

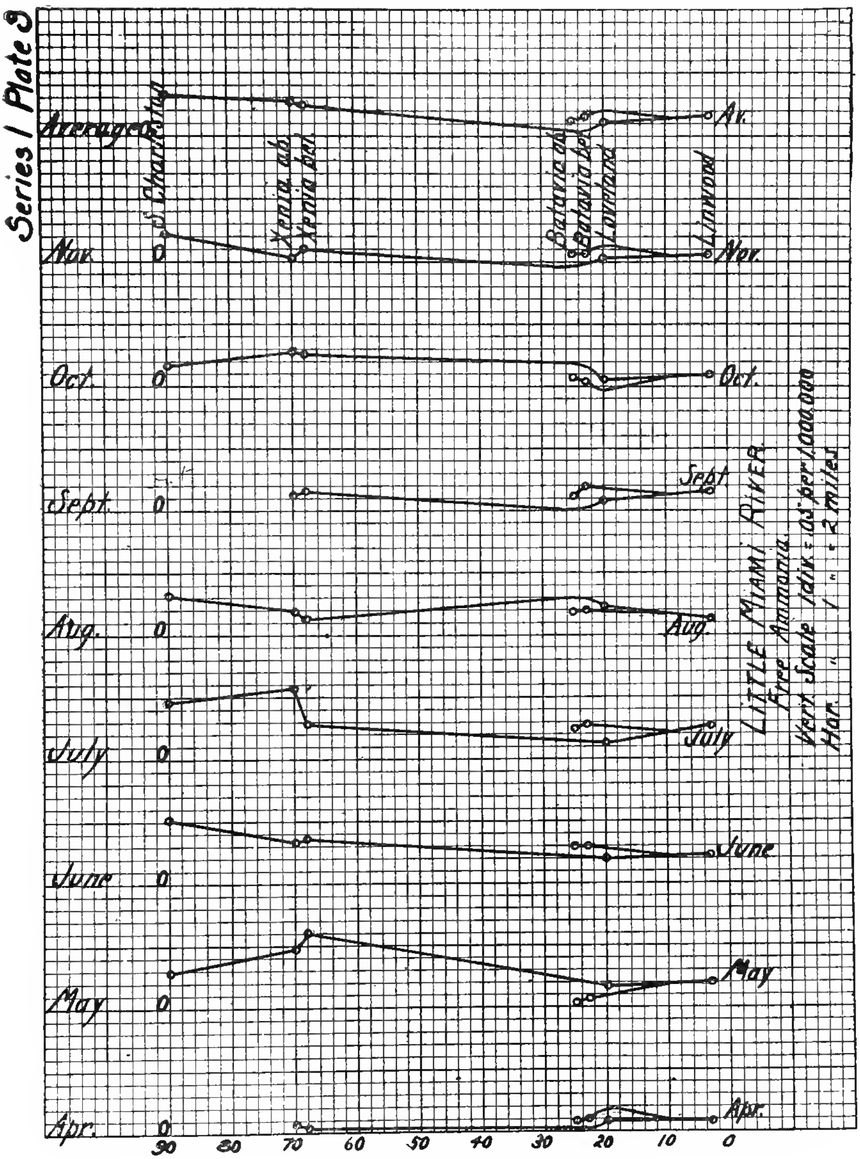
Curve "D" Great Miami River.
Piatc 23. Oxygen Required.
" 24. Nitrogen as Albuminoid Ammonia
" 25. Nitrogen as Free Ammonia.
" 26. Nitrogen as Nitrites.

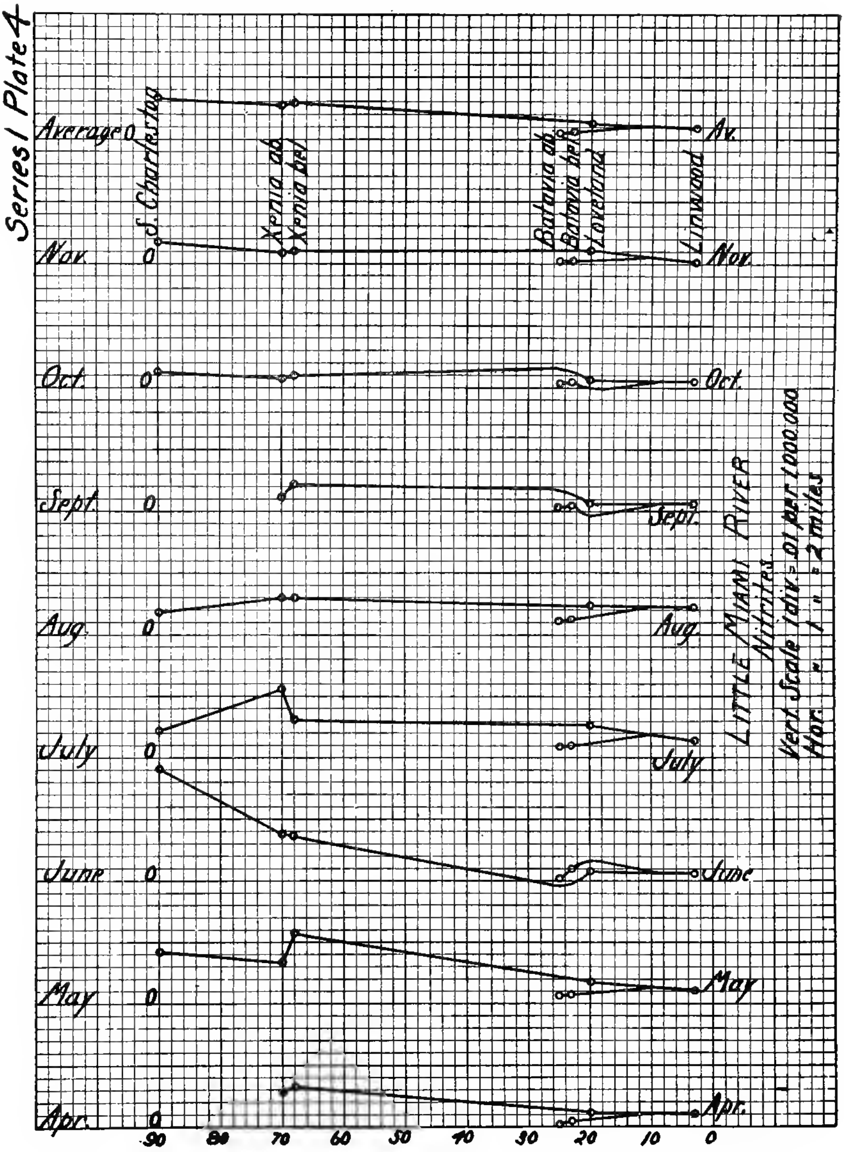
Plate 27. Nitrogen as Nitrates.
" 28. Chlorine.
" 29. Alkalinity.
" 30. Incrusting Constituents.
" 31. Total Solids.
" 32. Dissolved Oxygen.
" 33. Bacteria.



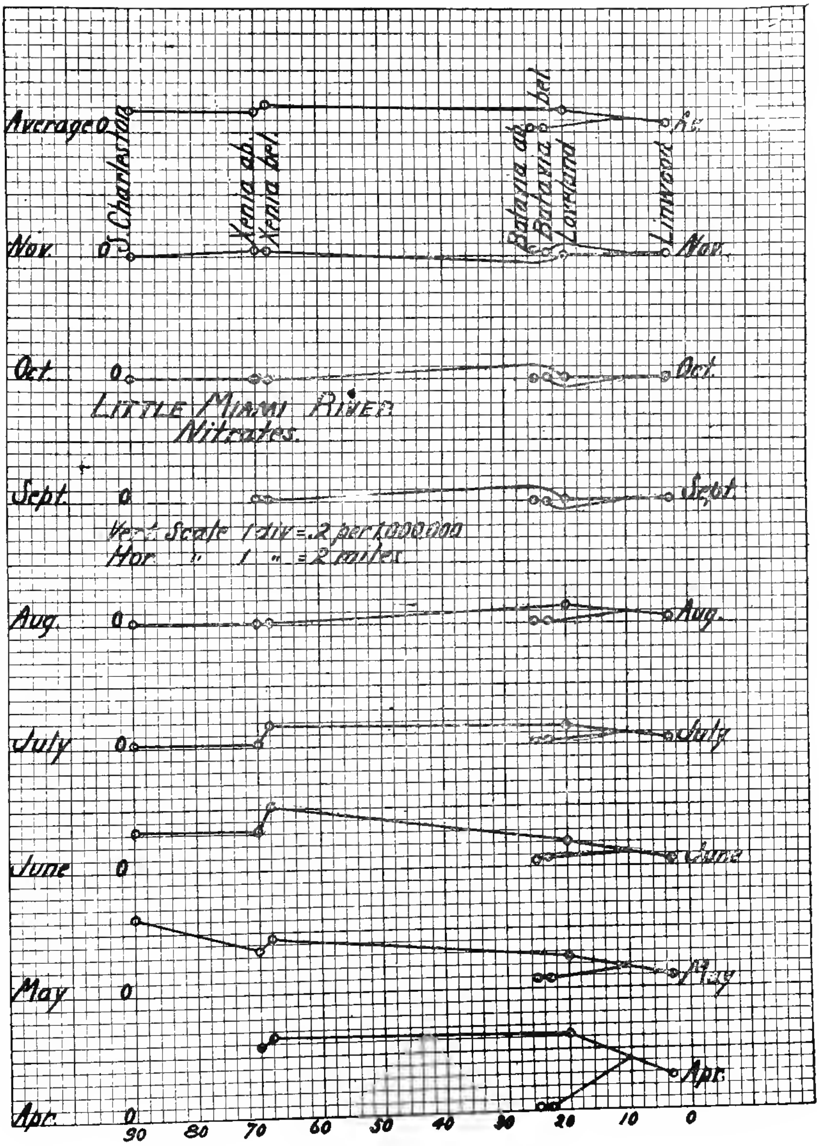


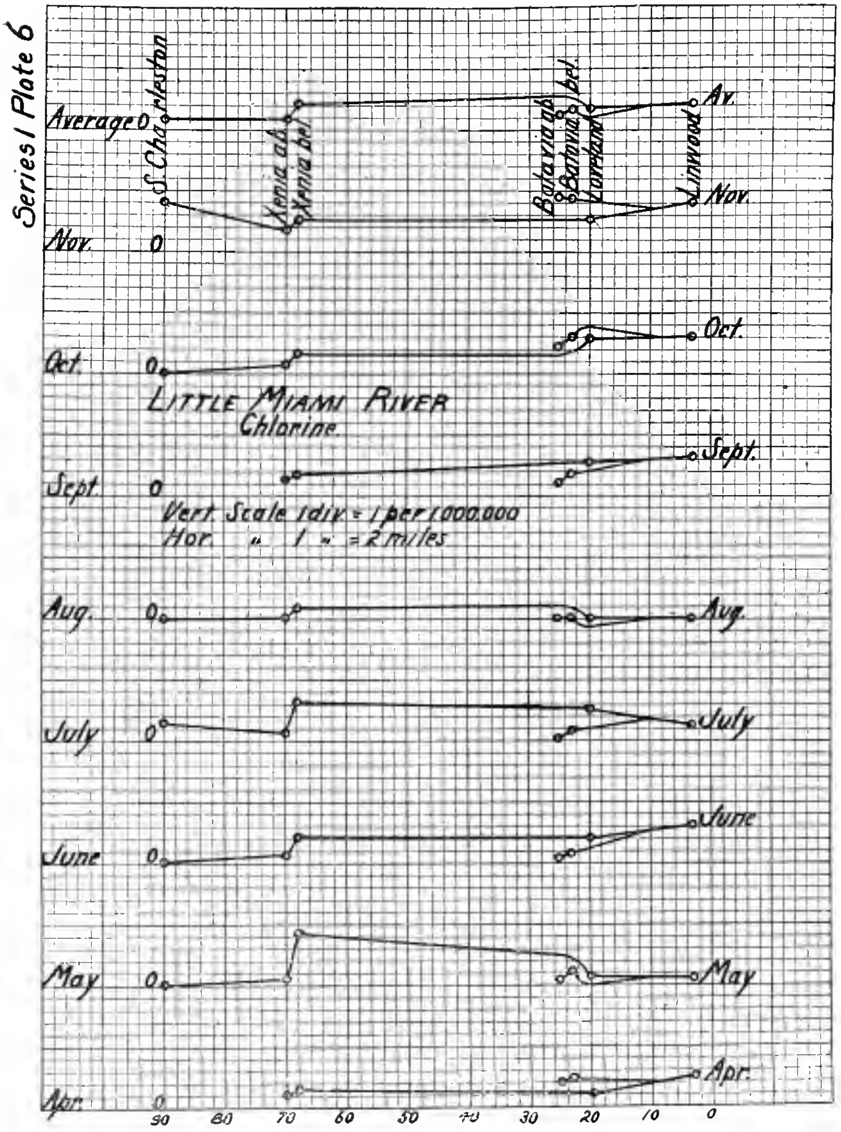
Series I Plate 2

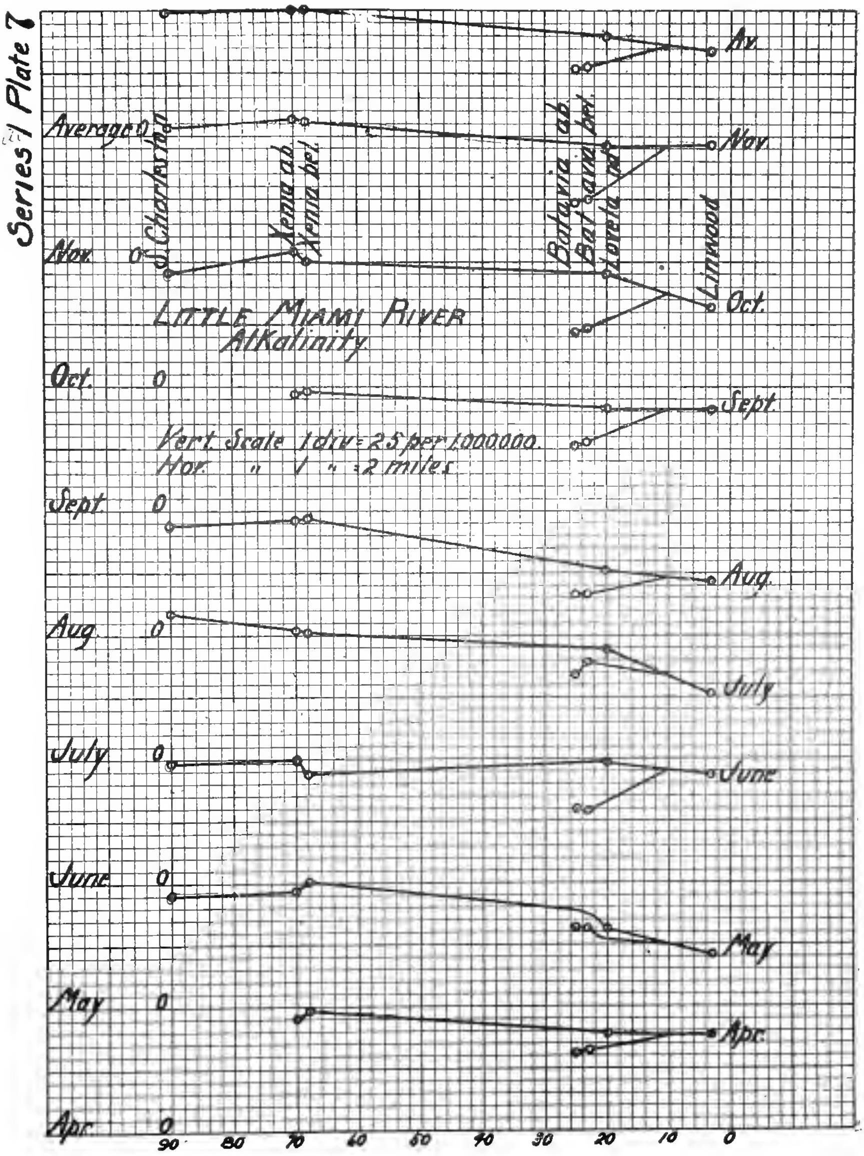

Series 1 Plate 9
Averages
Av.
S. Charleston
Xenia ab.
Xenia bel.
Batavia ab.
Batavia bel.
Loveland
Linwood
Nov.
Nov.
Oct.
Oct.
Sept.
Sept.
Aug.
Aug.
July
July
June
June
May
May
Apr.
Apr.
0
0
0
0
0
0
0
0
0
90
80
70
60
50
40
30
20
10
0
LITTLE MIAMI RIVER.
Free Ammonia.
Vert. Scale 1 div. = .03 per 1,000,000
Hor. " 1 " = 2 miles


Series 1 Plate 4
Average 0
Nov. 0
Oct. 0
Sept. 0
Aug. 0
July 0
June 0
May 0
Apr. 0
S. Charleston
Xenia ab.
Xenia bel.
Batavia ab.
Batavia bel.
Loveland
Linwood
Av.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
LITTLE MIAMI RIVER
Nitrites.
Vert. Scale 1 div. = .01 per 1000,000
Hor. " 1 " = 2 miles
90
80
70
60
50
40
30
20
10
0

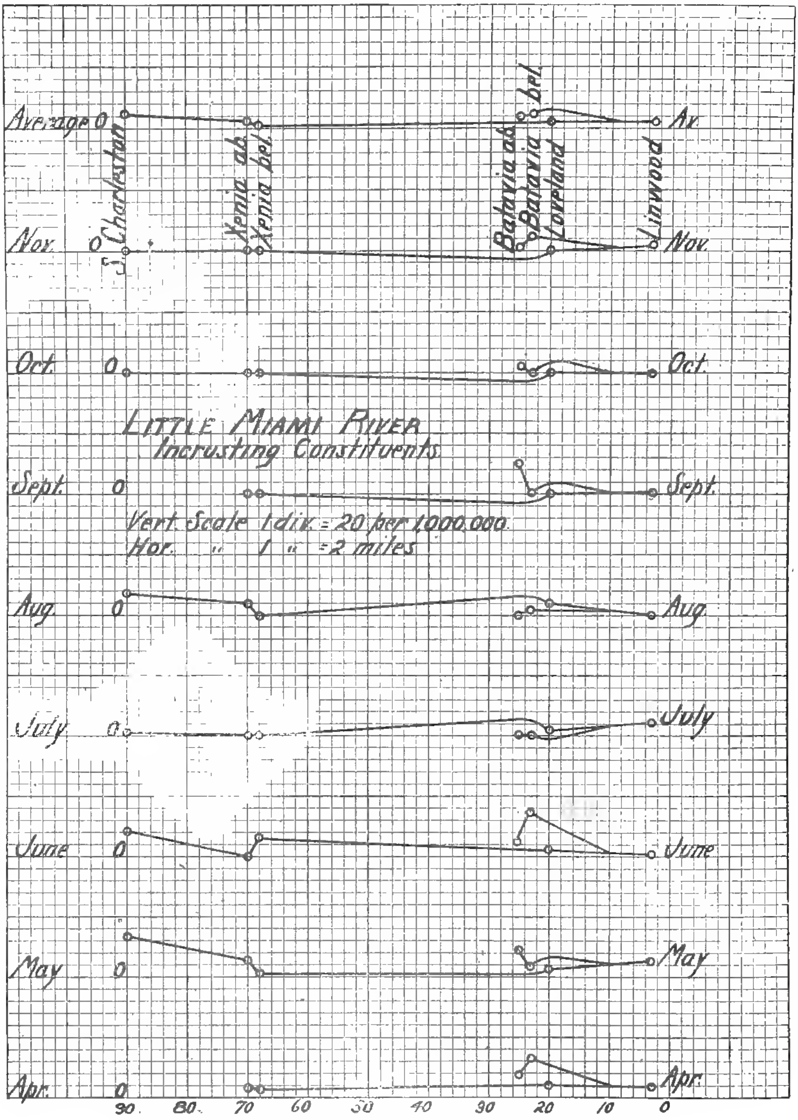
Series I Plate 5

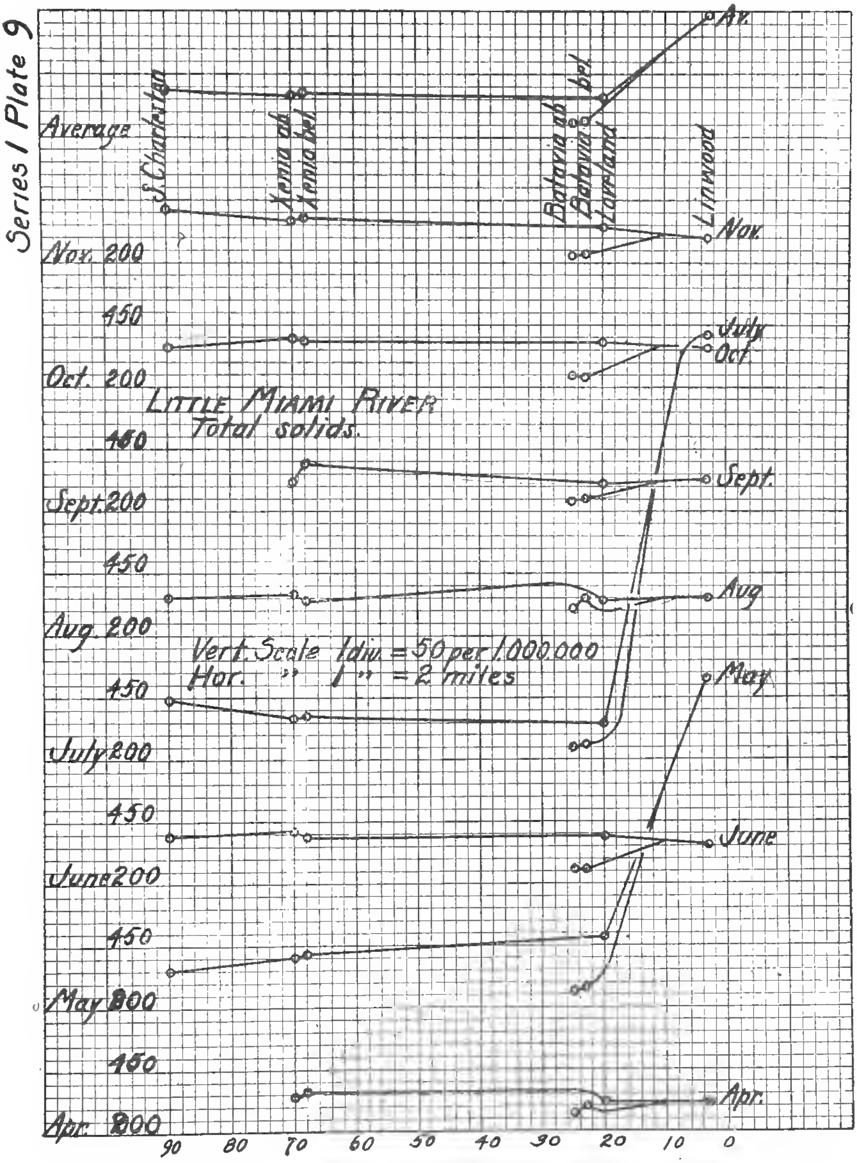



Series 1 Plate 6
Average 0
Av.
S. Charleston
Xenia ab.
Xenia bel.
Batavia ab.
Batavia bel.
Loveland
Linwood
Nov. 0
Nov.
Oct. 0
Oct.
LITTLE MIAMI RIVER
Chlorine.
Sept. 0
Sept.
Vert. Scale 1 div. = 1 per 1,000,000
Hor. " 1 " = 2 miles
Aug. 0
Aug.
July 0
July
June 0
June
May 0
May
Apr. 0
Apr.
90
80
70
60
50
40
30
20
10
0

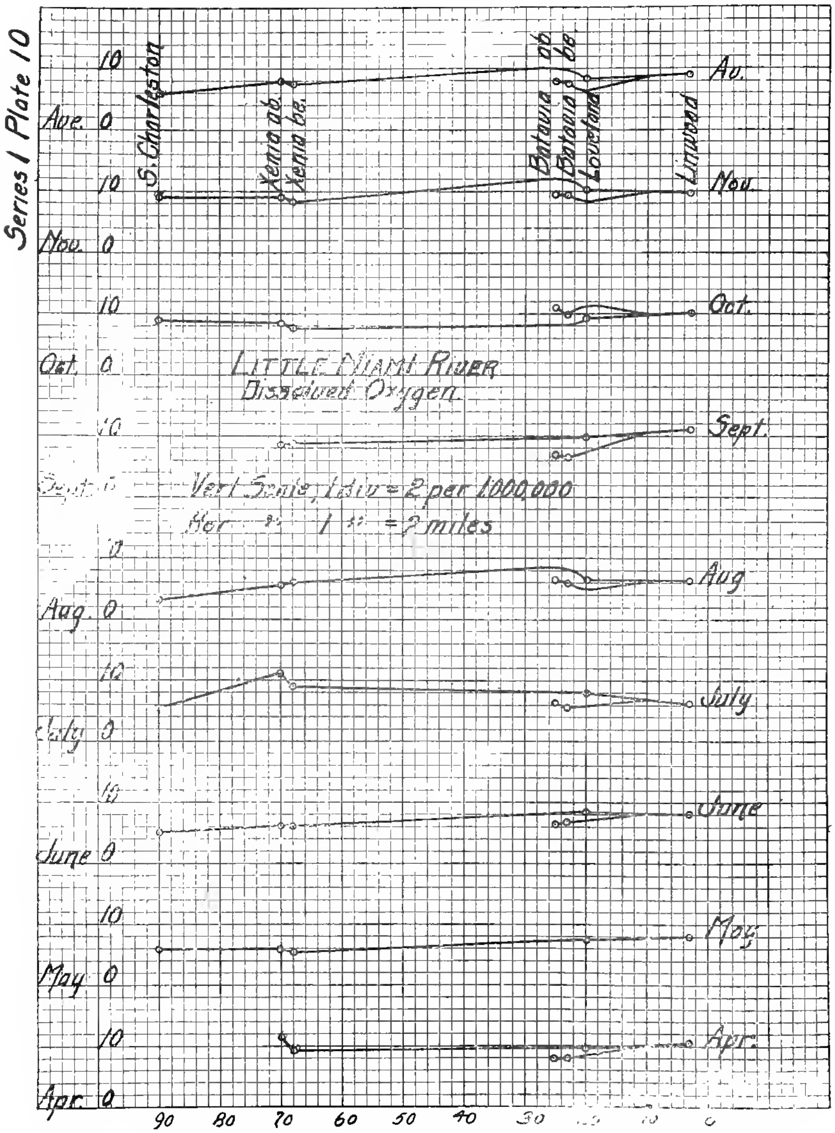

Series 1 Plate 7
LITTLE MIAMI RIVER
Alkalinity
Vert. Scale 1 div = 25 per 1,000,000.
Hor. " 1 " = 2 miles
S. Charleston
Xenia ab.
Xenia bel.
Batavia ab.
Bat. bel.
Loveland bel.
Linwood
Average 0
Nov. 0
Oct. 0
Sept. 0
Aug. 0
July 0
June 0
May 0
Apr. 0
Av.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
90
80
70
60
50
40
30
20
10
0

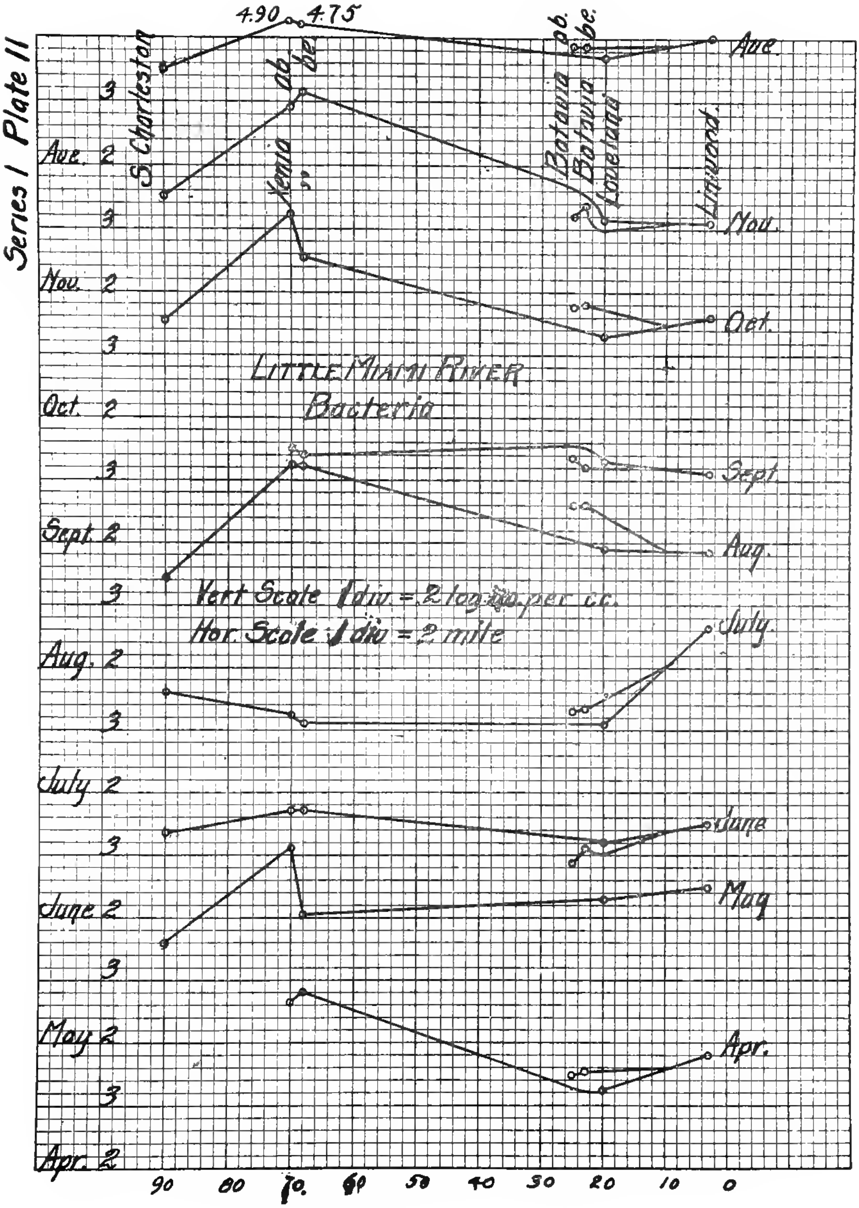
Series 1 Plate 8



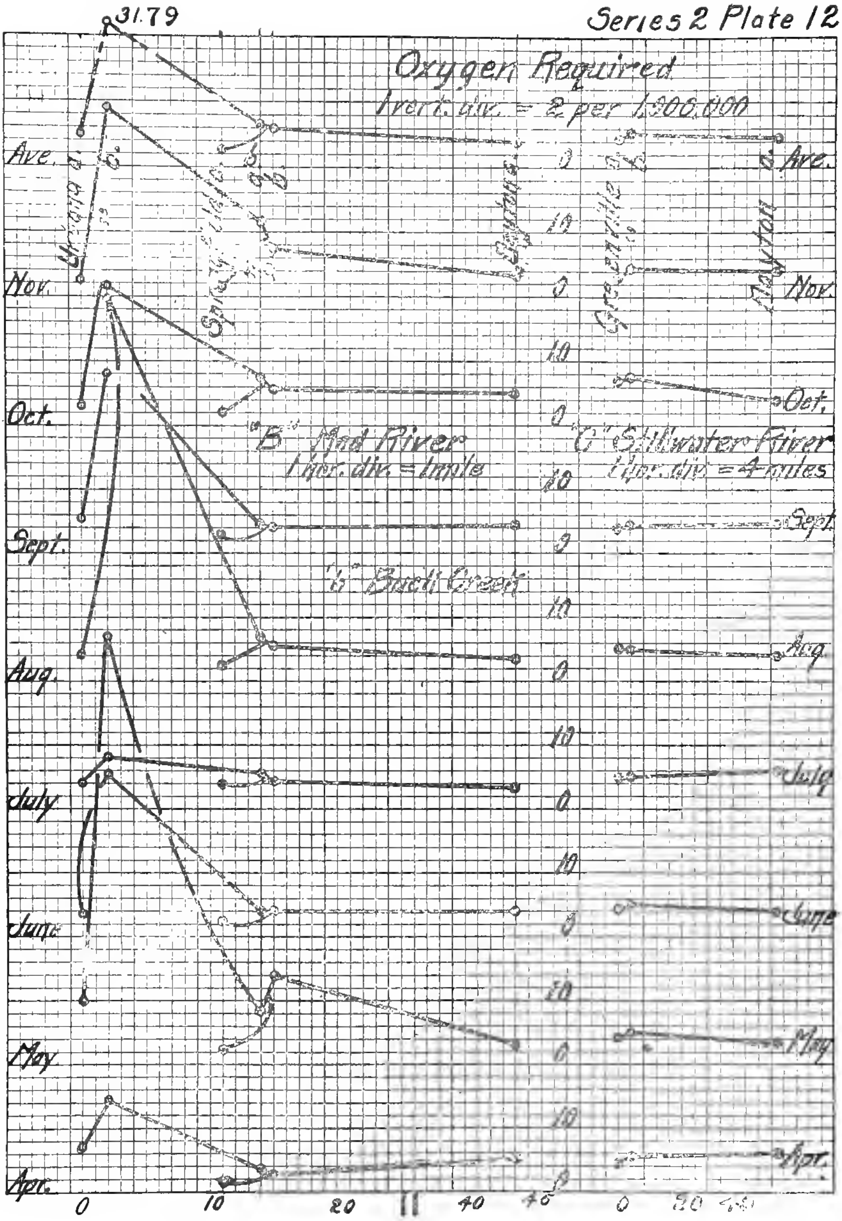


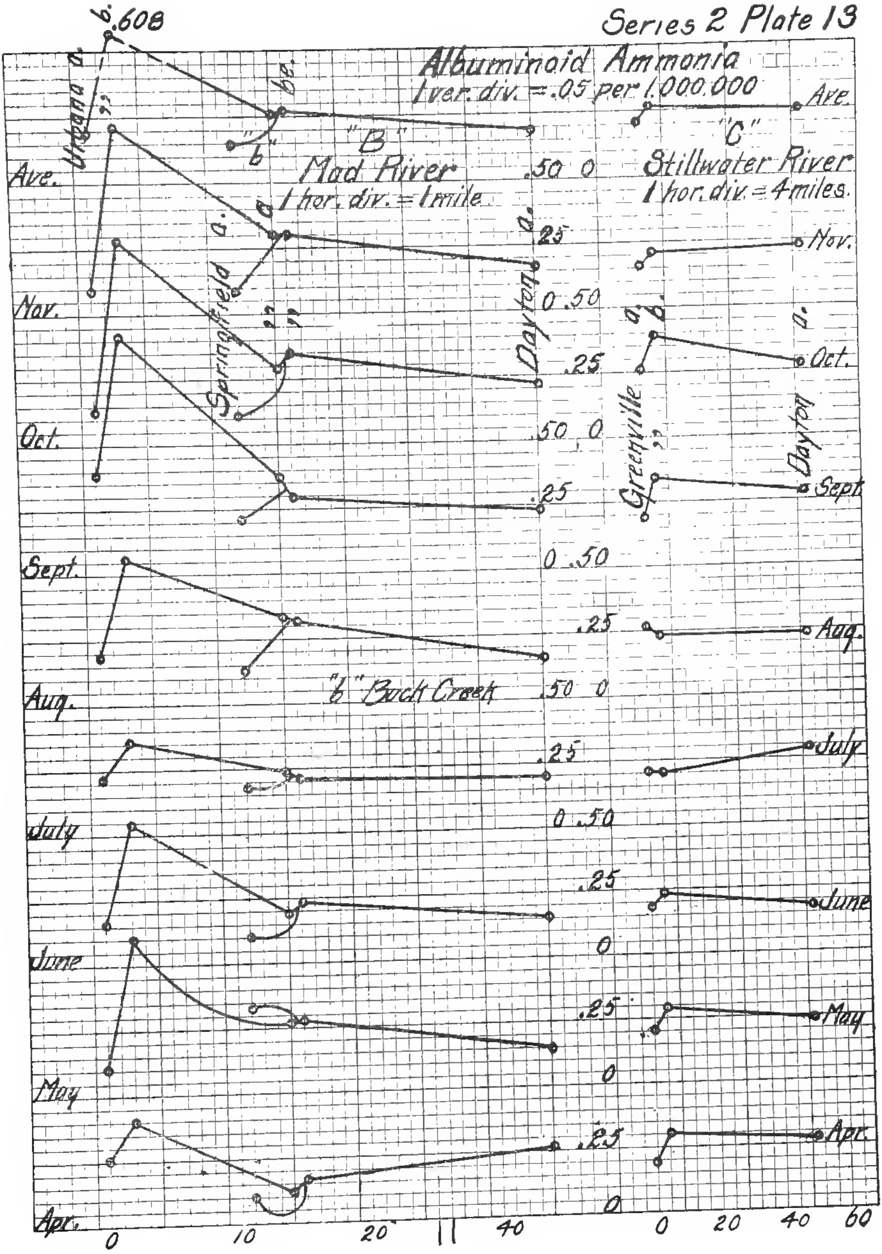
Series I Plate 9


Series 1 Plate 10
LITTLE MIAMI RIVER
Dissolved Oxygen.
Vert Scale, 1 div = 2 per 1,000,000
Hor " 1 " = 2 miles
S. Charleston
Xenia ab.
Xenia be.
Batavia ab.
Batavia be.
Loveland
Linwood
Av.
Nov.
Oct.
Sept.
Aug
July
June
May
Apr.
Ave. 0
Nov. 0
Oct. 0
Sept. 0
Aug. 0
July 0
June 0
May 0
Apr. 0
10
90
80
70
60
50
40
30
20
10
0

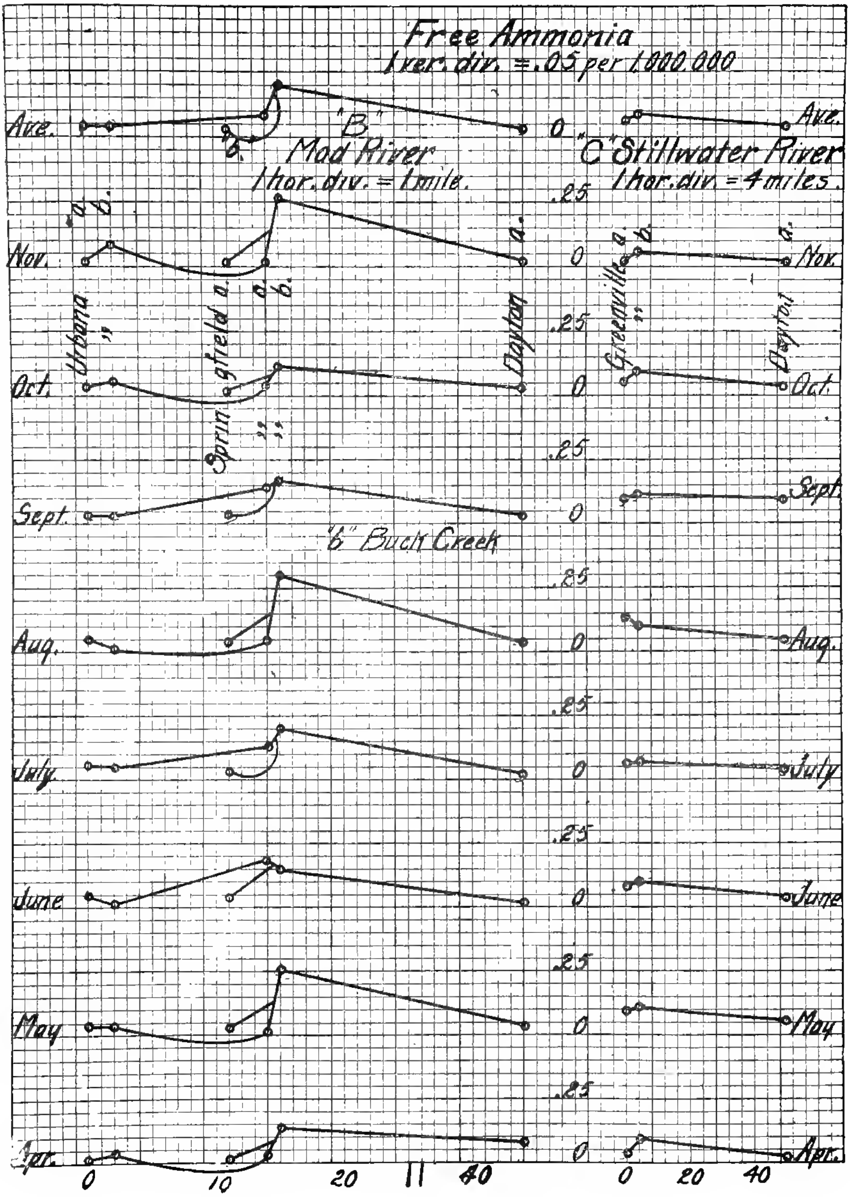

Series I Plate II
LITTLE MIAMI RIVER
Bacteria
Vert Scale 1 div = .2 log no. per cc.
Hor. Scale 1 div = 2 mile
S. Charleston
Xenia ob.
be.
Batavia ob.
Batavia be.
Loveland
Linwood
4.90
4.75
Ave.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
Ave. 2
3
Nov. 2
3
Oct. 2
3
Sept. 2
3
Aug. 2
3
July 2
3
June 2
3
May 2
3
Apr. 2
90
80
70.
60
50
40
30
20
10
0

Series 2 Plate 12

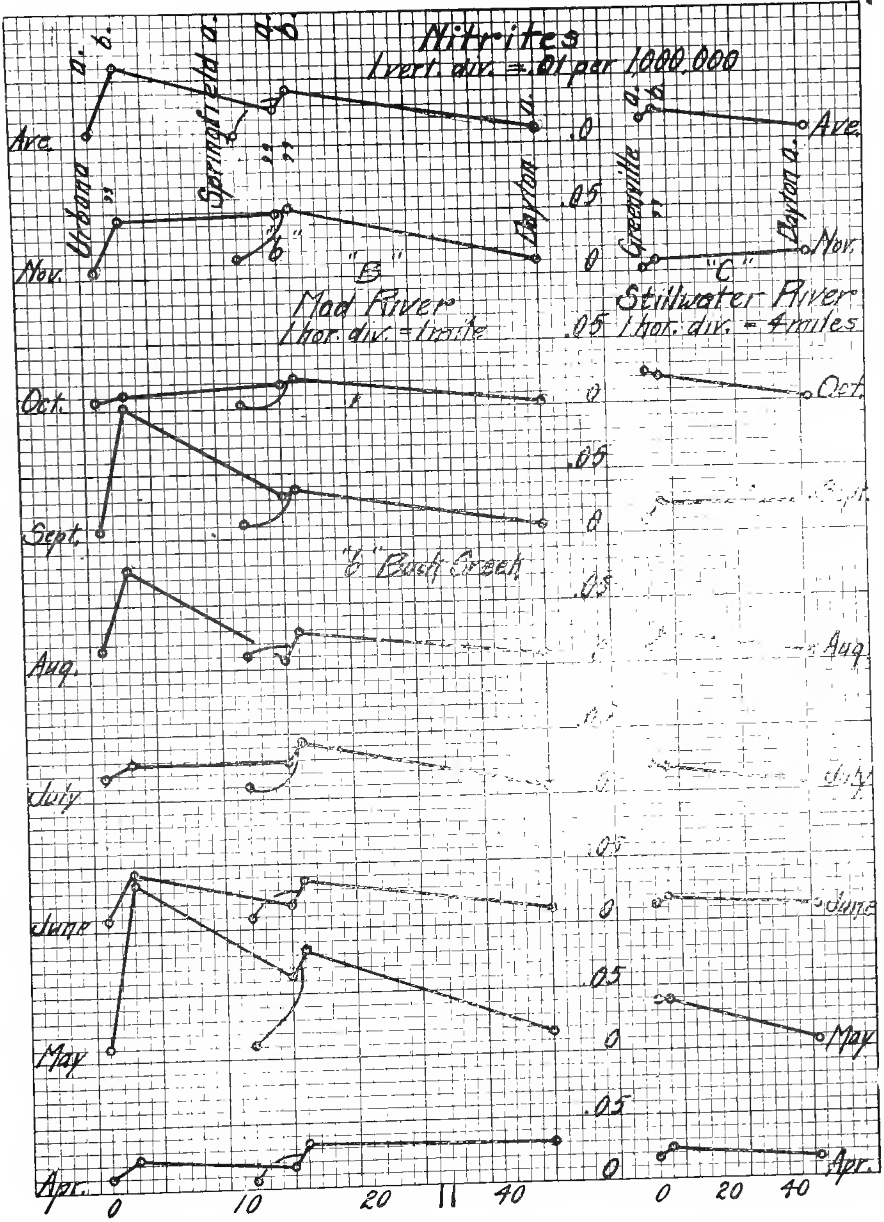



Series 2 Plate 13
Albuminoid Ammonia
1 ver. div. = .05 per 1,000,000
"B"
Mad River
1 hor. div. = 1 mile
"C"
Stillwater River
1 hor. div. = 4 miles.
"b" Buck Creek
.608
Urbana a.
b.
Springfield a.
c.
"b"
ba.
Dayton a.
Greenville a.
b.
Dayton a.
Ave.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
.50
.25
0
0
10
20
40
0
20
40
60

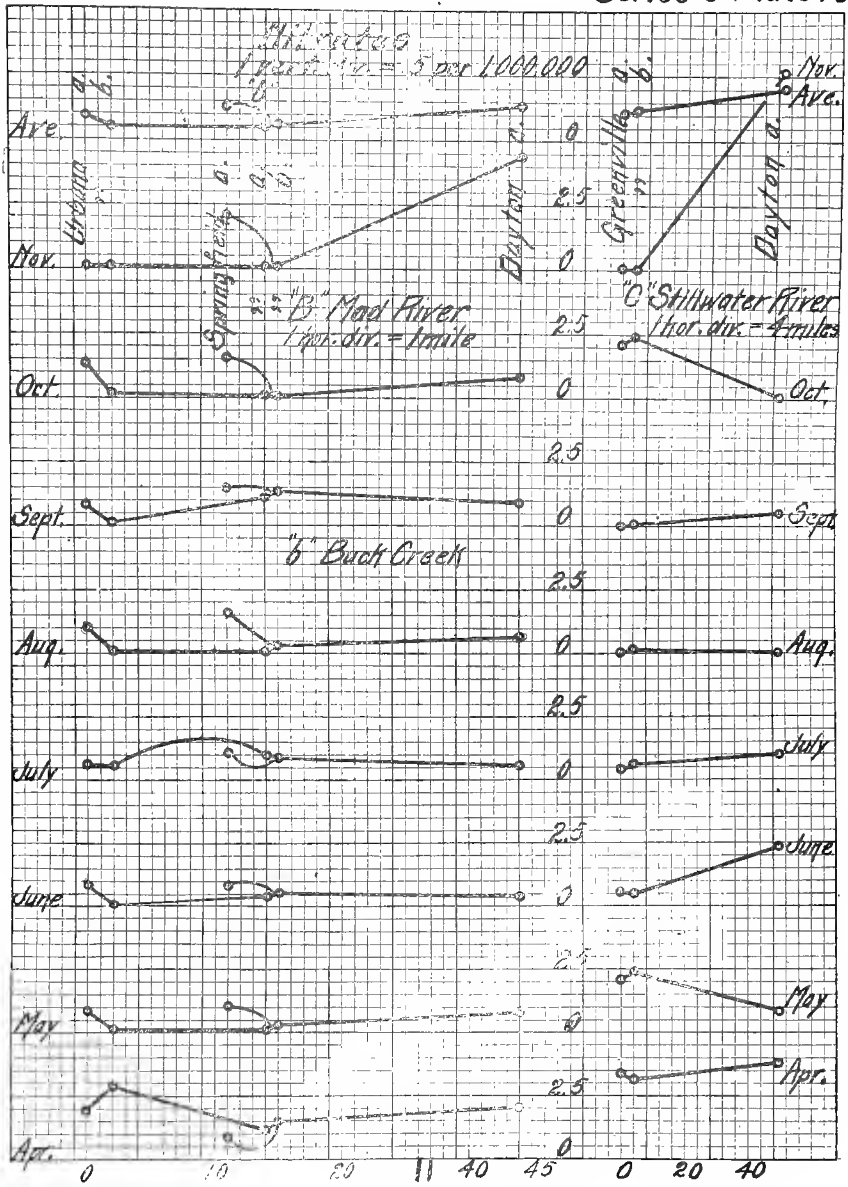
Series 2 Plate 14



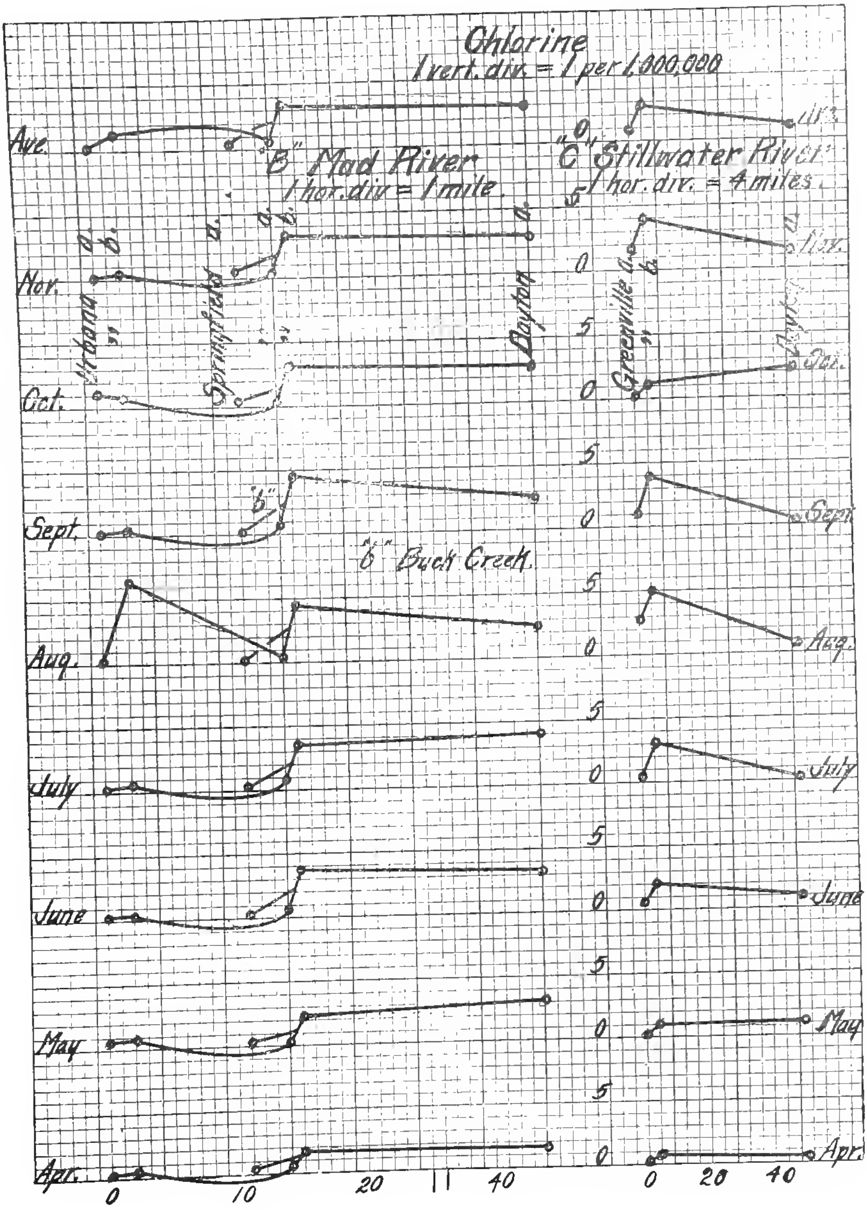
Series 2 Plate 15.



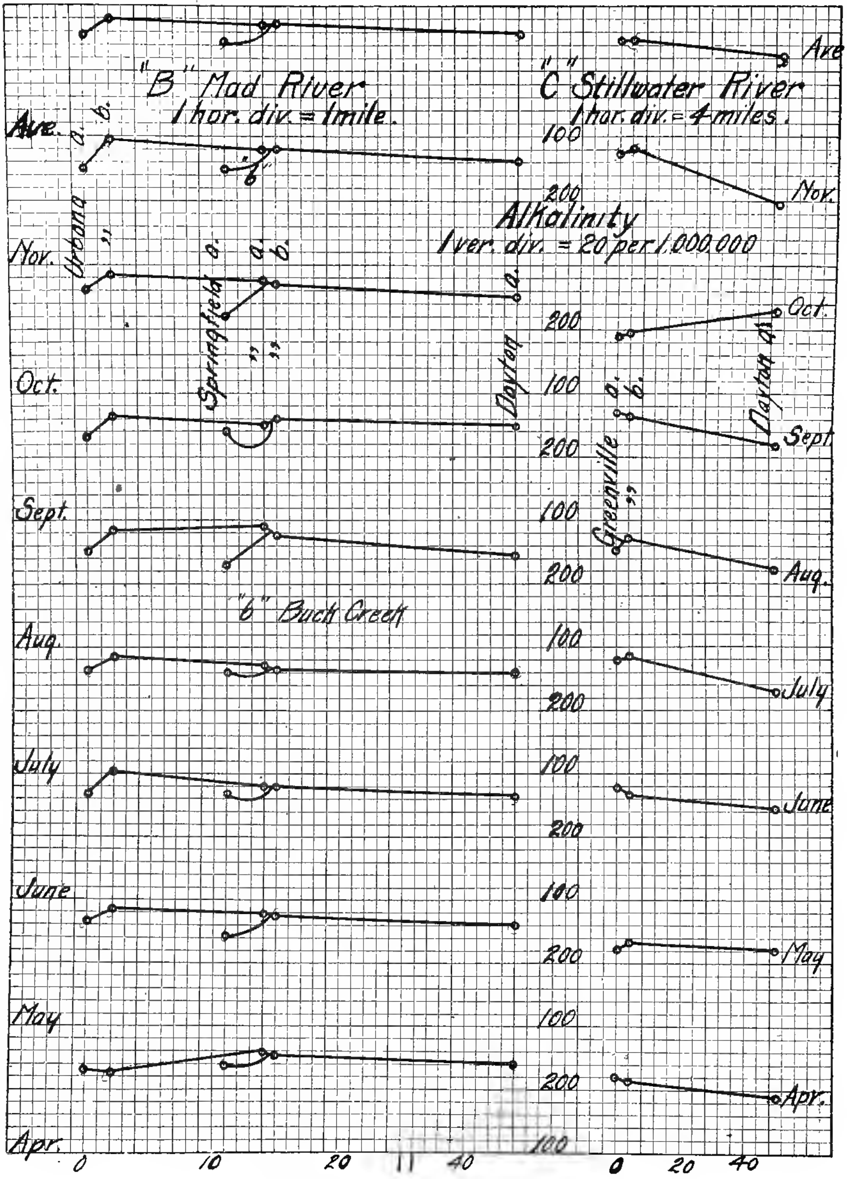
Series 2 Plate 16



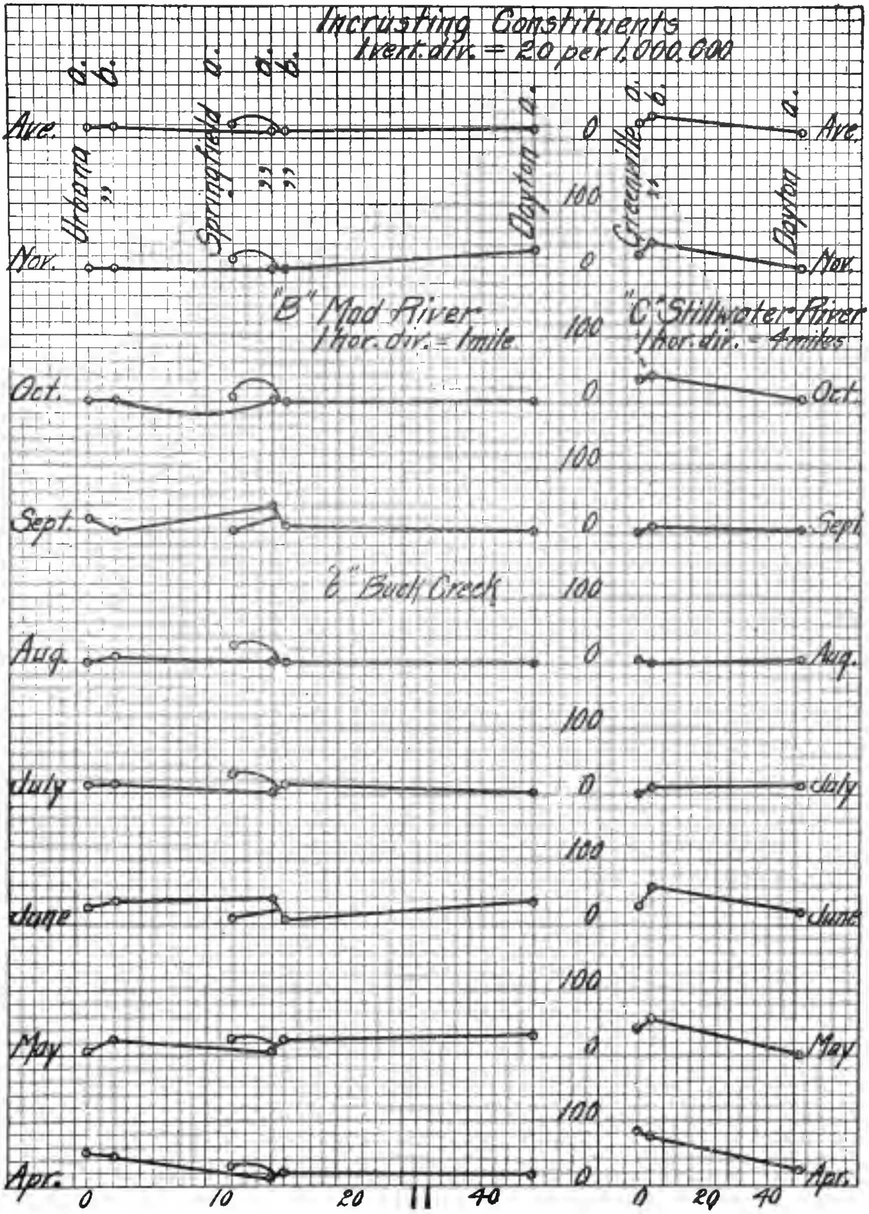
Series 2 Plate 17

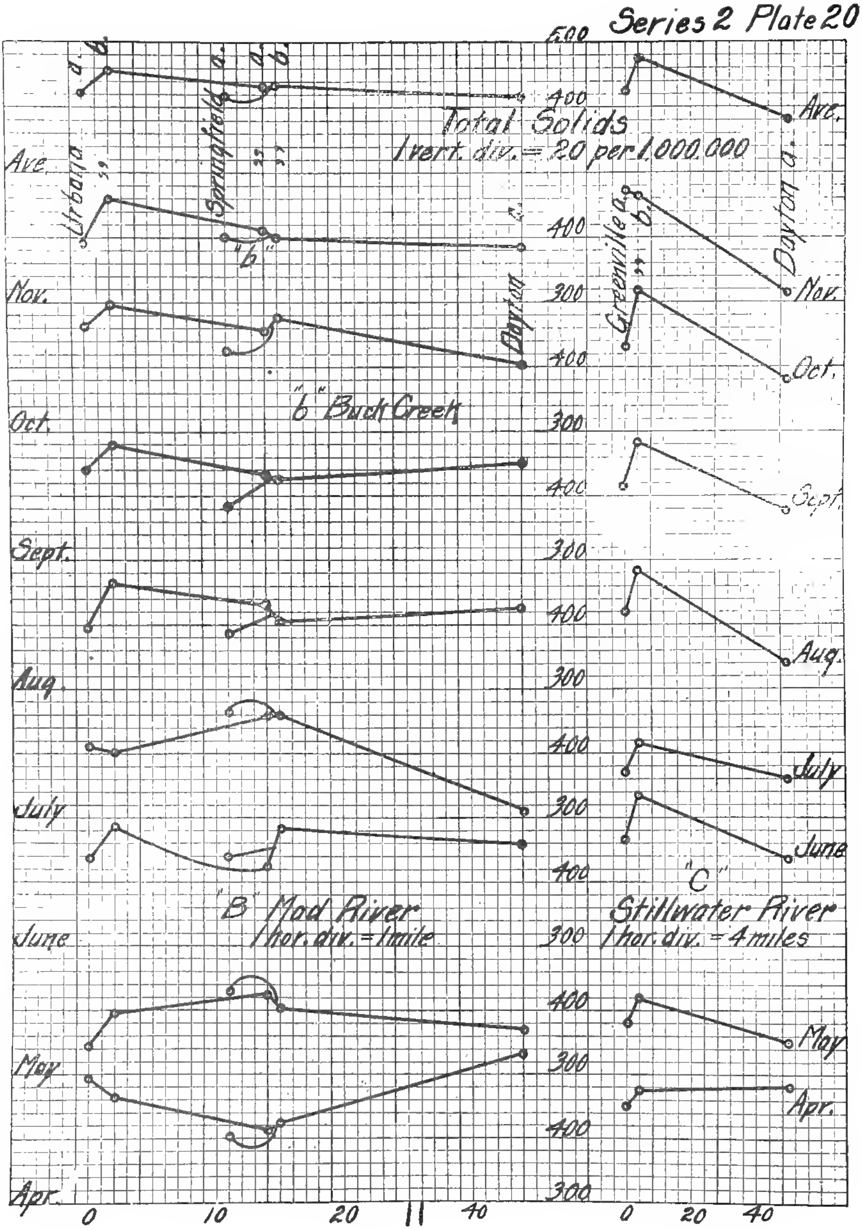


Series 2 Plate 18

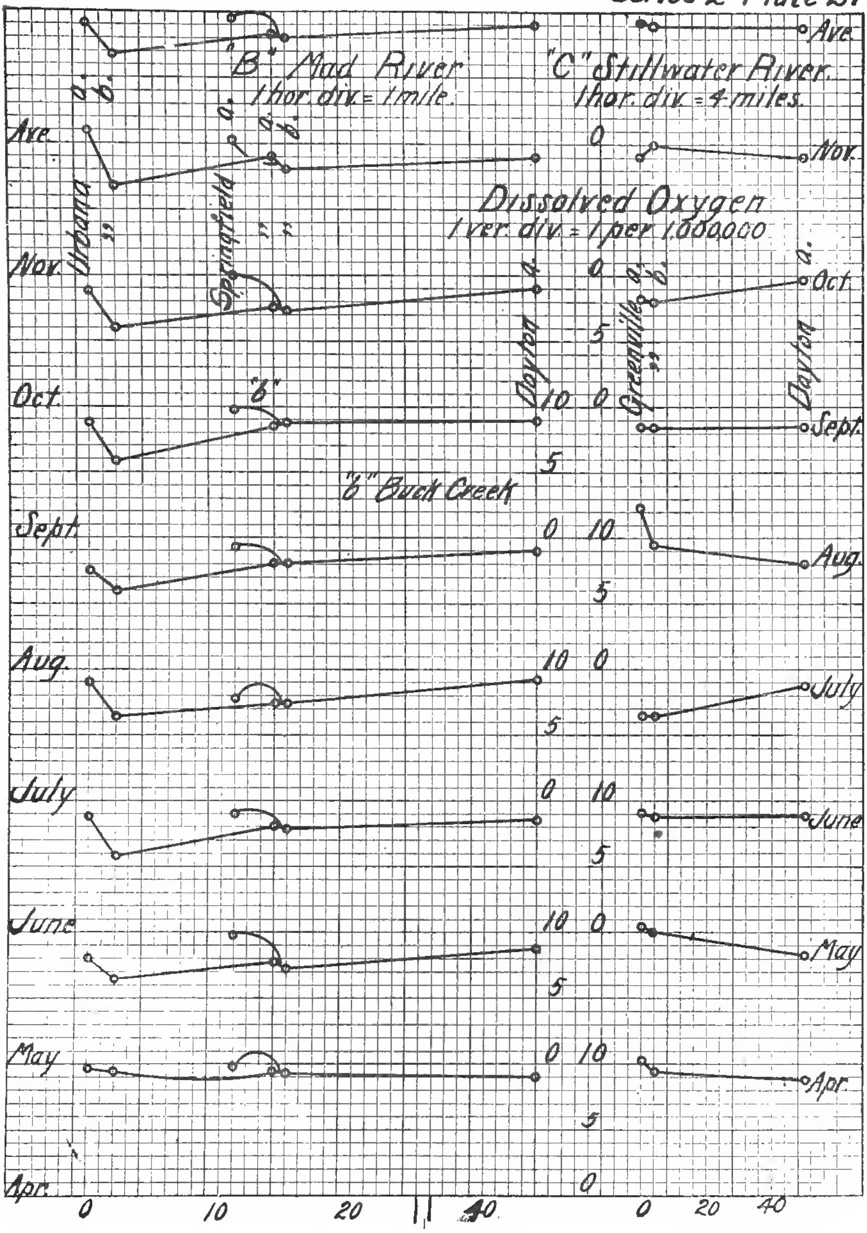


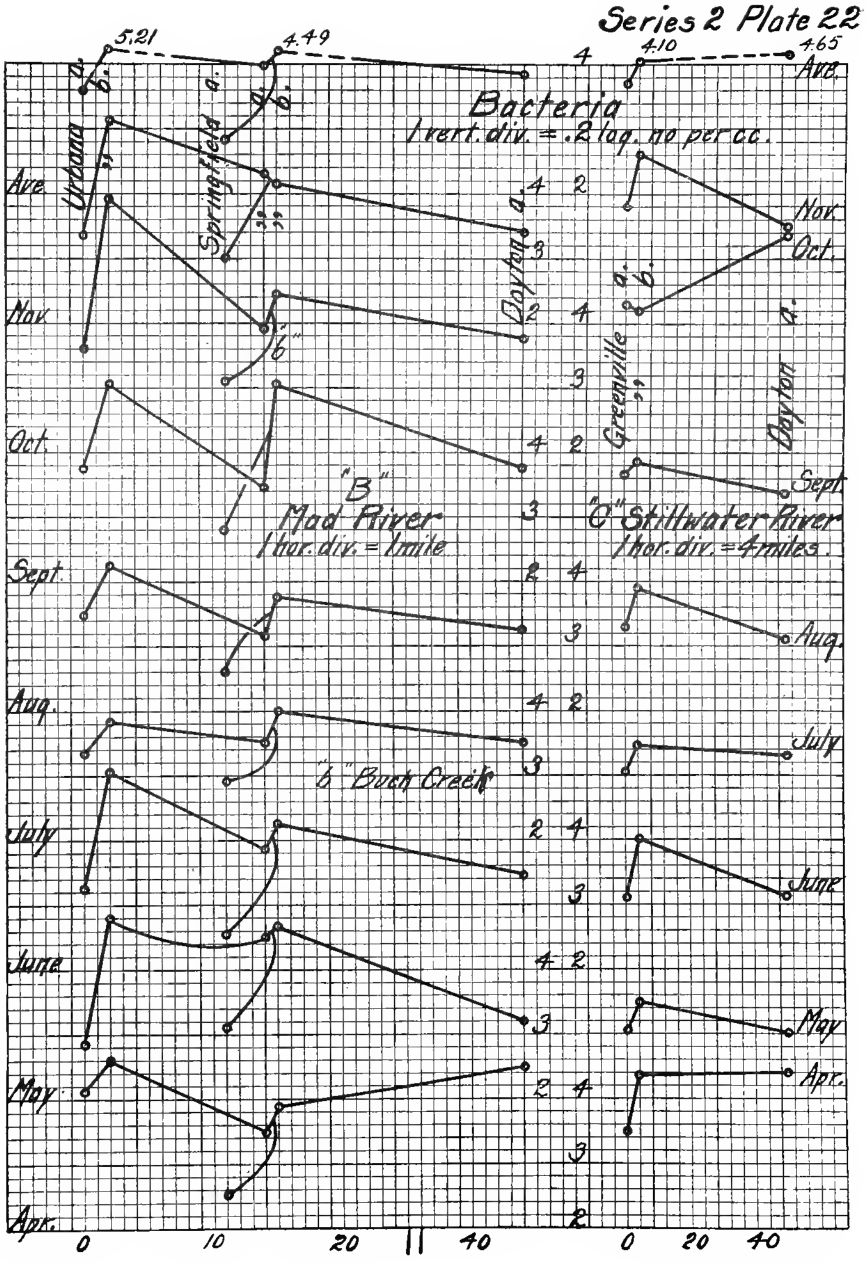
Series 2 Plate 19

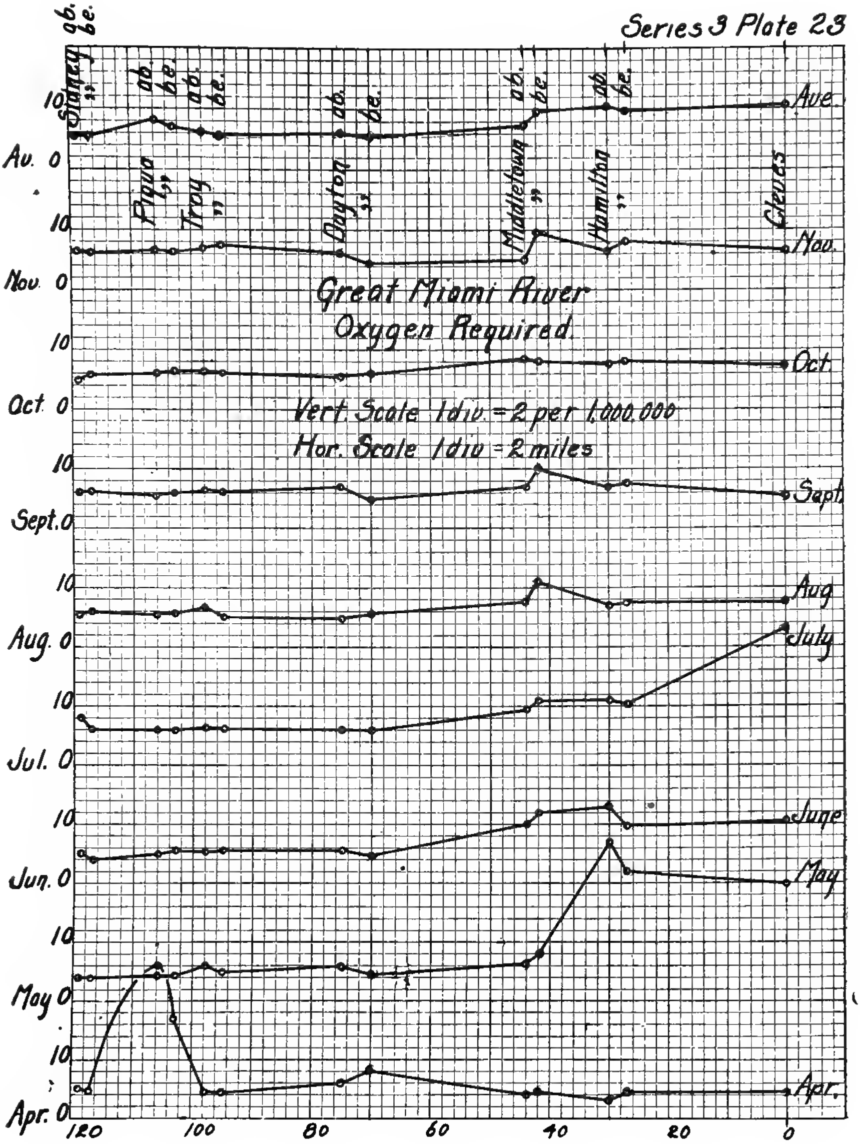



Series 2 Plate 20
Total Solids
1 vert. div. = 20 per 1,000,000
Urbana a. b.
Springfield a. b.
"b"
Dayton a.
Greenville a. b.
Dayton a.
"b" Buck Creek
"B" Mad River
1 hor. div. = 1 mile
"C"
Stillwater River
1 hor. div. = 4 miles
Ave.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
500
400
300
0
10
20
40
0
20
40

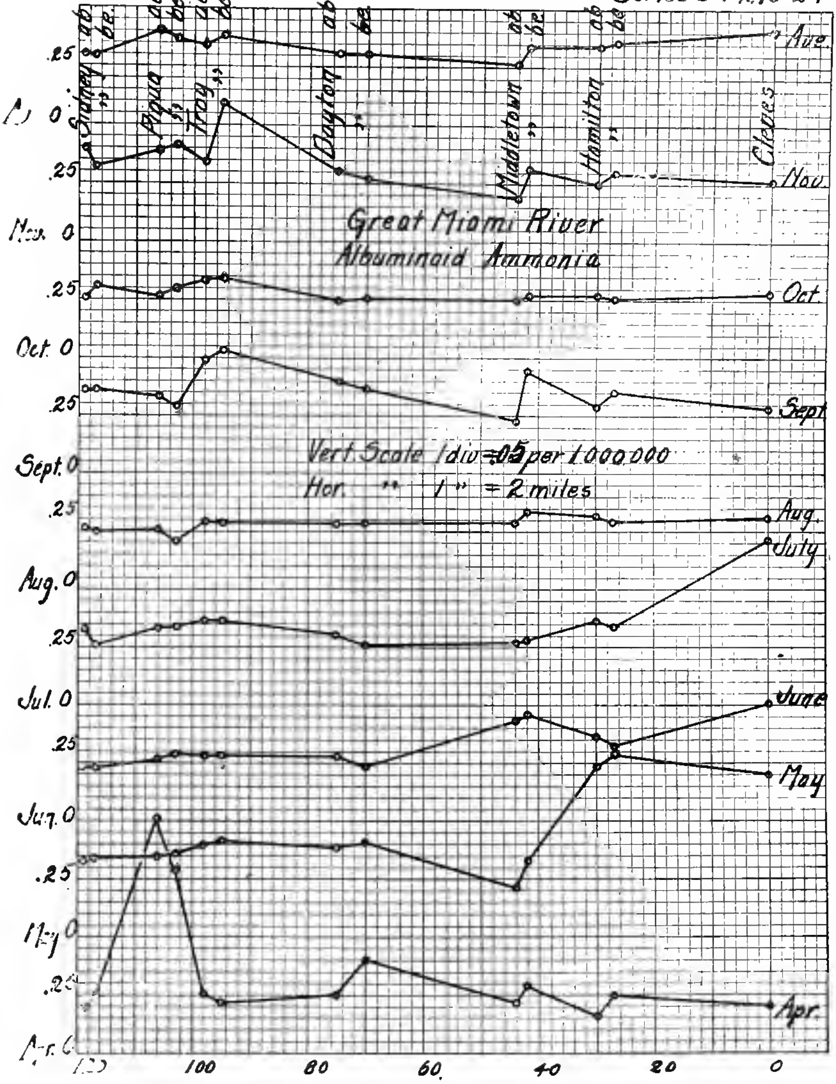
Series 2 Plate 21

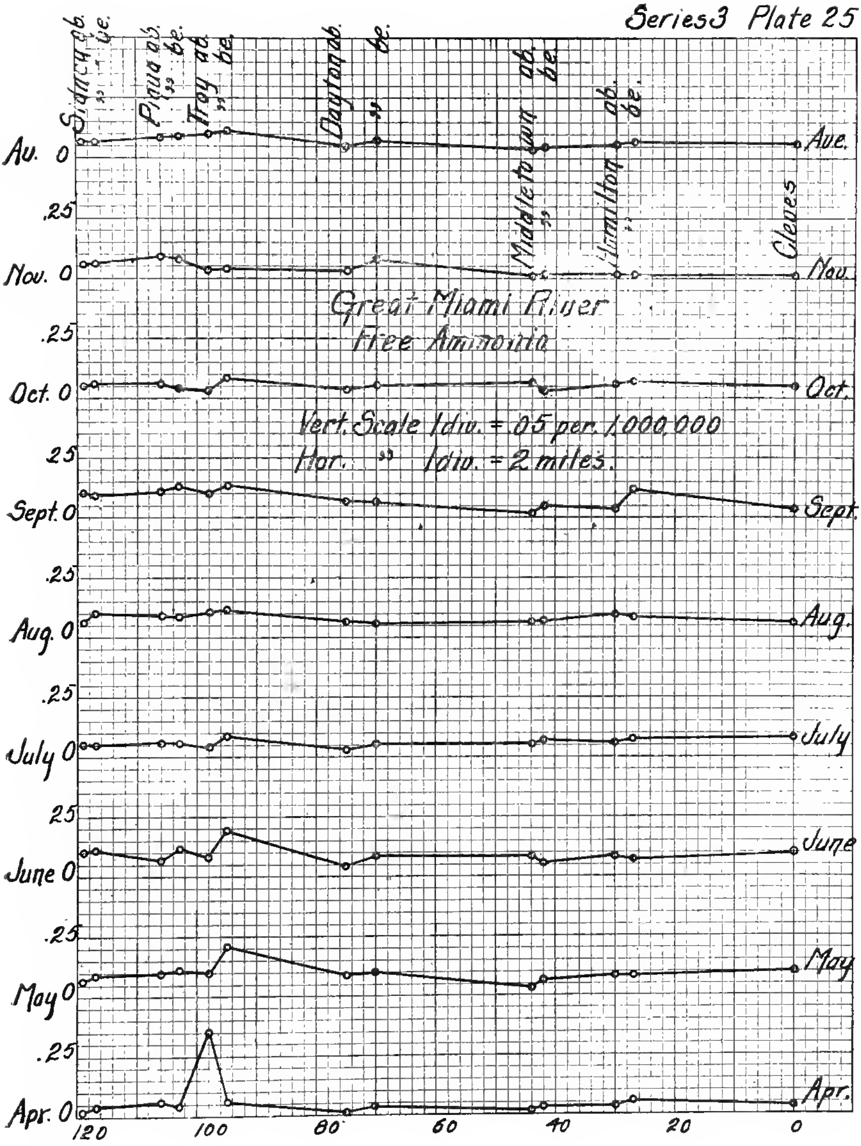


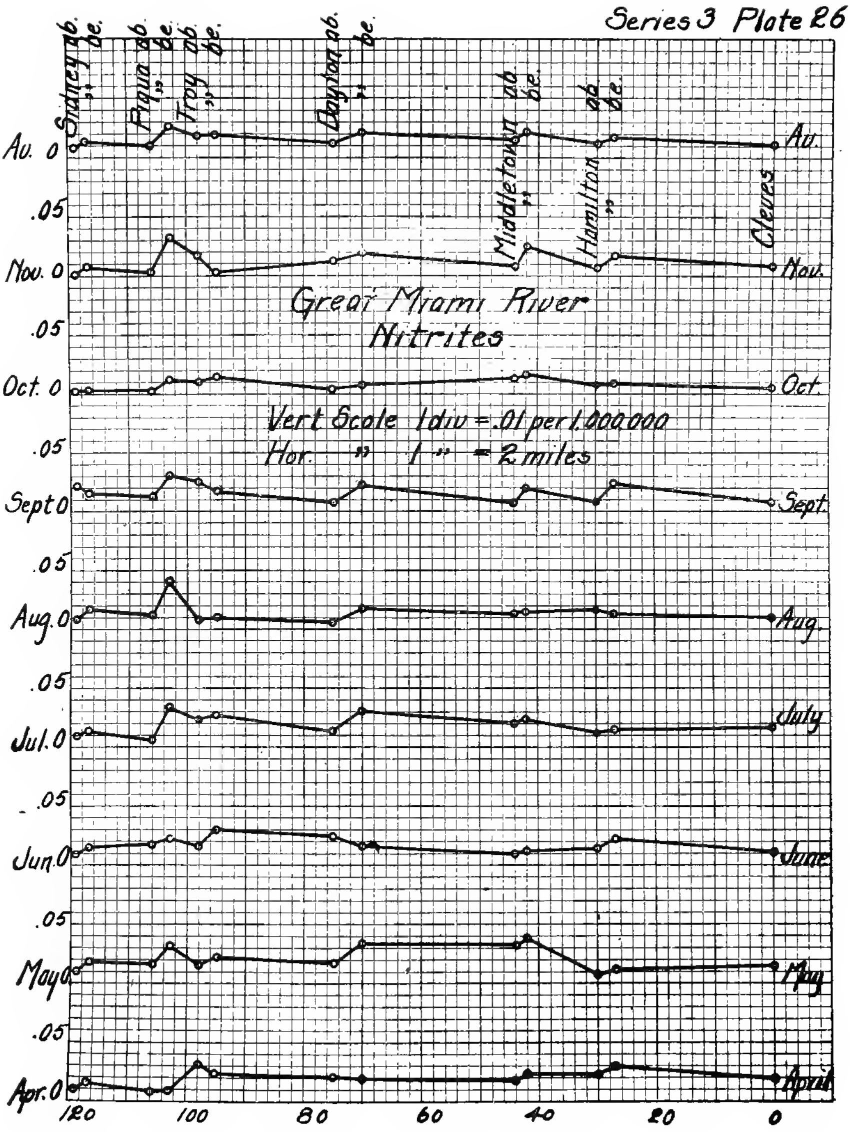

Series 2 Plate 22
Bacteria
1 vert. div. = .2 log. no per cc.
"B" Mad River
1 hor. div. = 1 mile
"C" Stillwater River
1 hor. div. = 4 miles
Urbana a.
b.
Springfield a.
b.
Dayton a.
Greenville a.
b.
Dayton a.
"b" Buck Creek
5.21
4.49
4.10
4.65
Ave.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
0
10
20
40
0
20
40

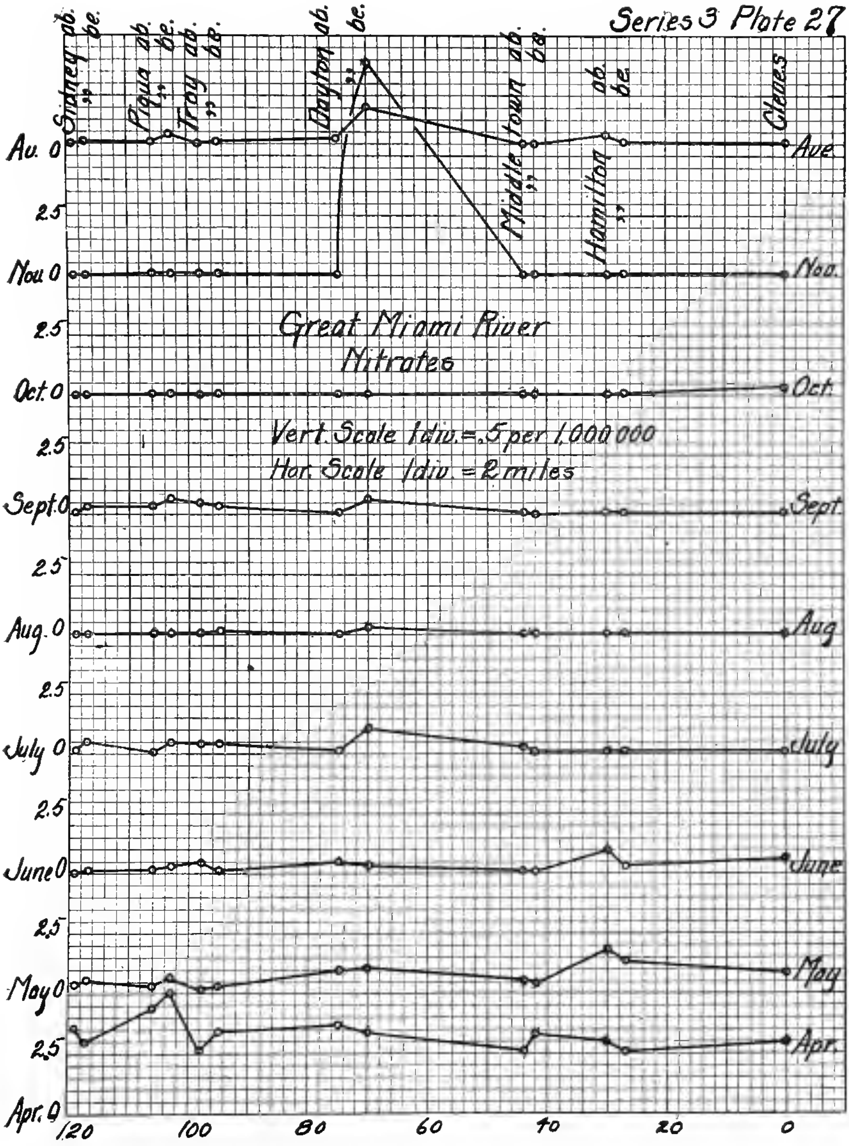

Series 3 Plate 23
Great Miami River
Oxygen Required
Vert. Scale 1 div. = 2 per 1,000,000
Hor. Scale 1 div. = 2 miles
Sidney
Piqua
Troy
Dayton
Middletown
Hamilton
Cleves
ab.
be.
Ave.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
Av. 0
Nov. 0
Oct. 0
Sept. 0
Aug. 0
Jul. 0
Jun. 0
May 0
Apr. 0
10
120
100
80
60
40
20
0

Series 3 Plate 24

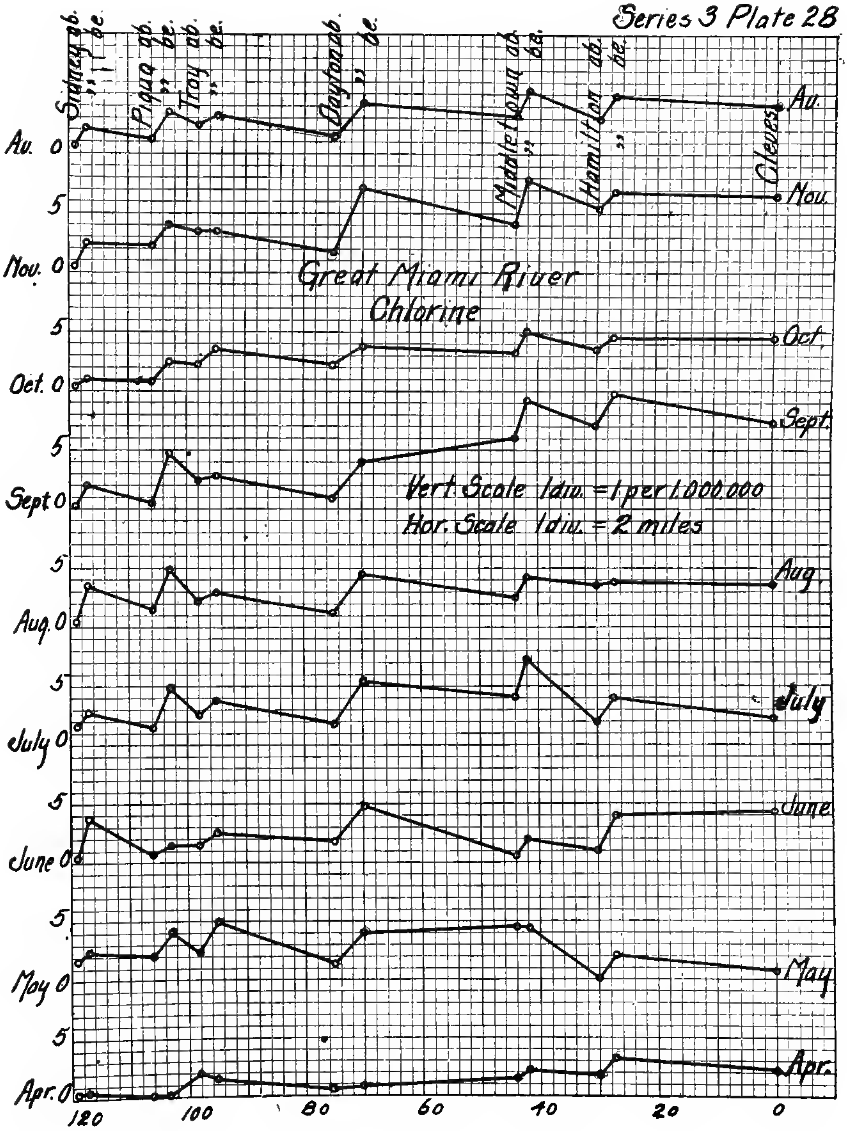


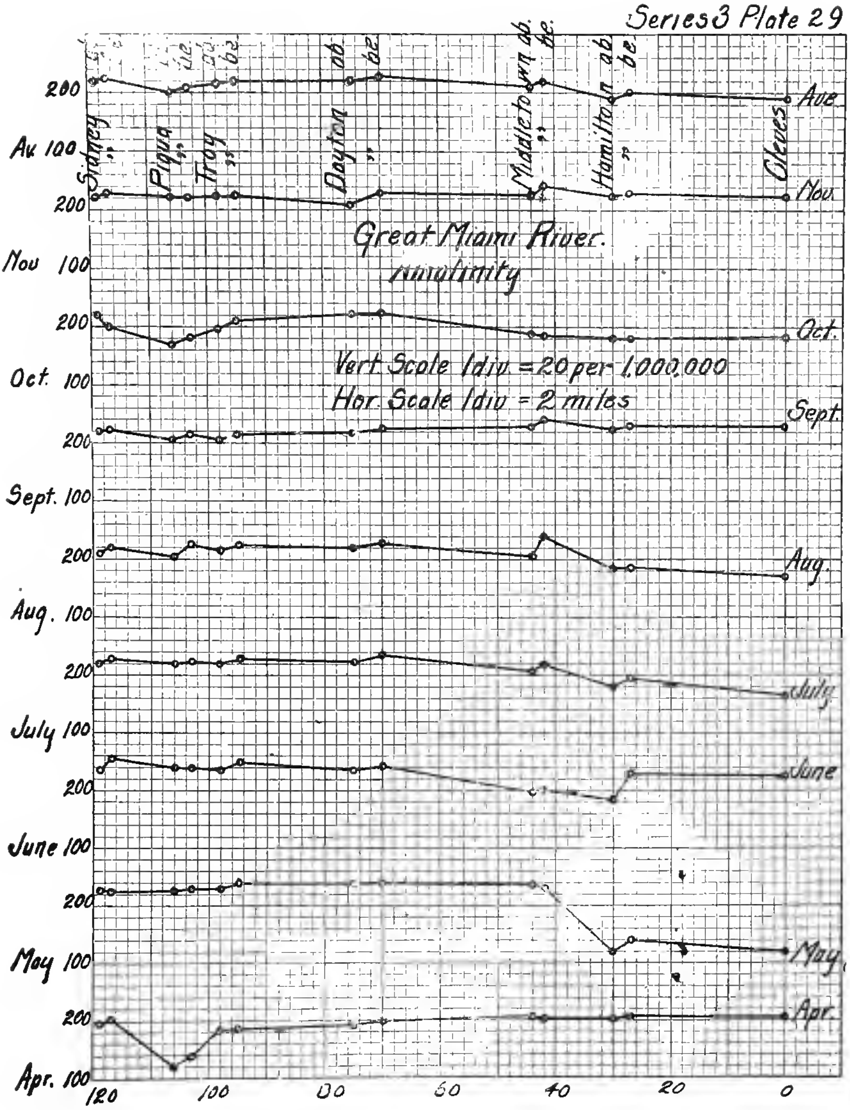

Series 3 Plate 25
Sidney ab.
" be.
Piqua ab.
" be.
Troy ab.
" be.
Dayton ab.
" be.
Middletown ab.
" be.
Hamilton ab.
" be.
Cleves
Great Miami River
Free Ammonia
Vert. Scale 1 div. = .05 per. 1,000,000
Hor. " 1 div. = 2 miles.
Av. 0
.25
Nov. 0
.25
Oct. 0
.25
Sept. 0
.25
Aug. 0
.25
July 0
.25
June 0
.25
May 0
.25
Apr. 0
Ave.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
120
100
80
60
40
20
0

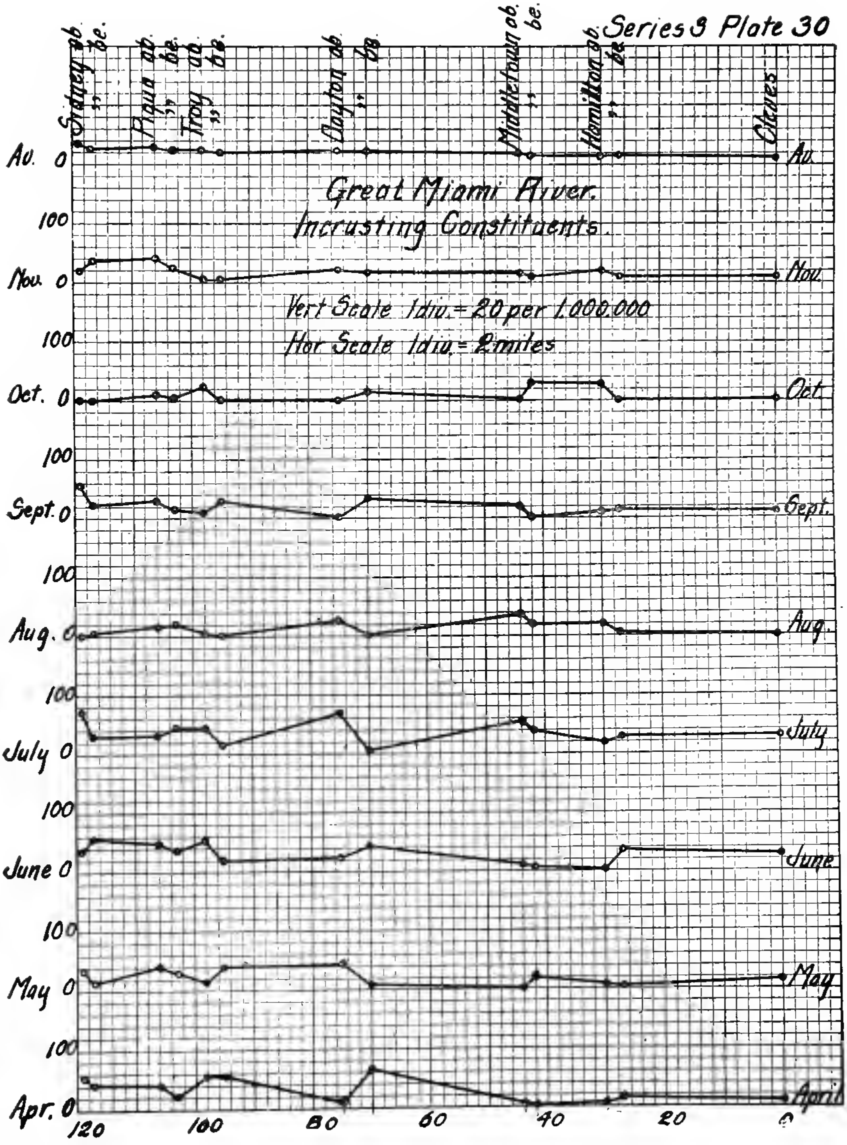

Series 3 Plate 26
Sidney ab.
" be.
Piqua ab.
" be.
Troy ab.
" be.
Dayton ab.
" be.
Middletown ab.
" be.
Hamilton ab.
" be.
Cleves
Great Miami River
Nitrites
Vert Scale 1 div = .01 per 1,000,000
Hor. " 1 " = 2 miles
Au. 0
.05
Nov. 0
.05
Oct. 0
.05
Sept 0
.05
Aug. 0
.05
Jul. 0
.05
Jun. 0
.05
May 0
.05
Apr. 0
Au.
Nov.
Oct.
Sept.
Aug.
July
June
May
April
120
100
80
60
40
20
0

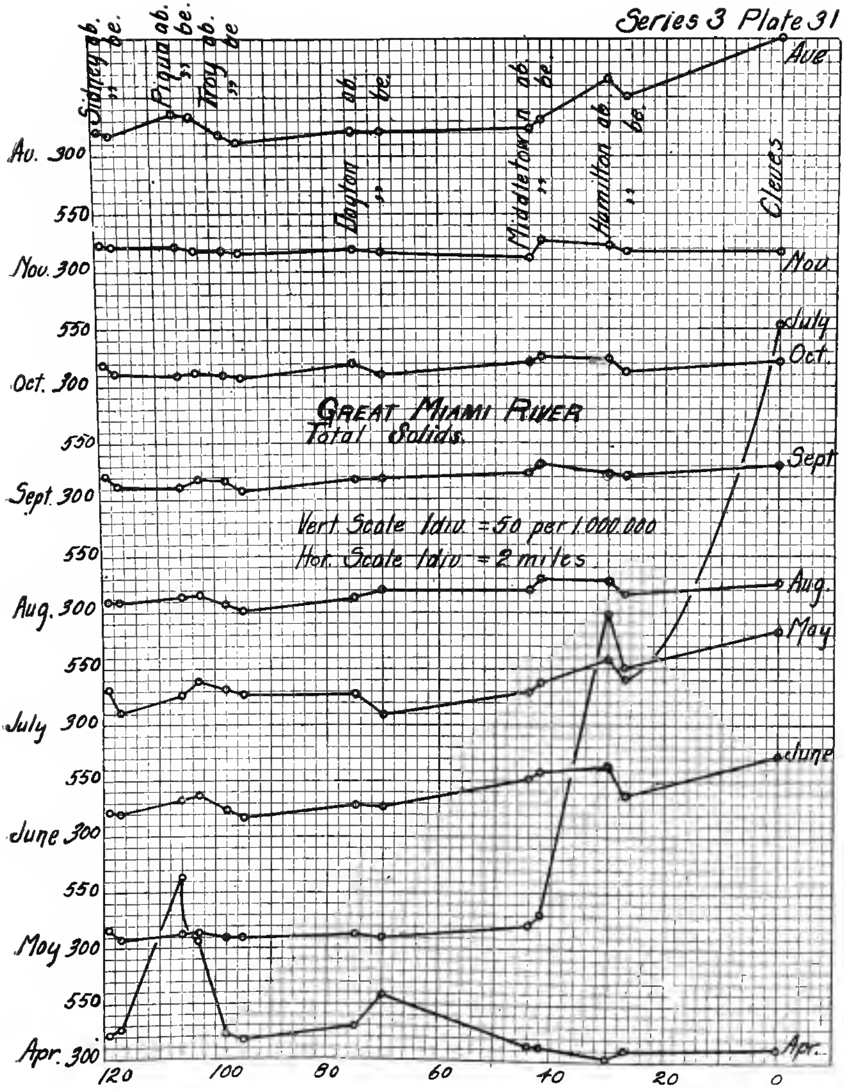

Series 3 Plate 27
Sidney ab.
" be.
Piqua ab.
" be.
Troy ab.
" be.
Dayton ab.
" be.
Middletown ab.
" be.
Hamilton ab.
" be.
Cleves
Great Miami River
Nitrates
Vert. Scale 1 div. = .5 per 1,000,000
Hor. Scale 1 div. = 2 miles
Av. 0
2.5
Nov. 0
2.5
Oct. 0
2.5
Sept. 0
2.5
Aug. 0
2.5
July 0
2.5
June 0
2.5
May 0
2.5
Apr. 0
Ave.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
120
100
80
60
40
20
0

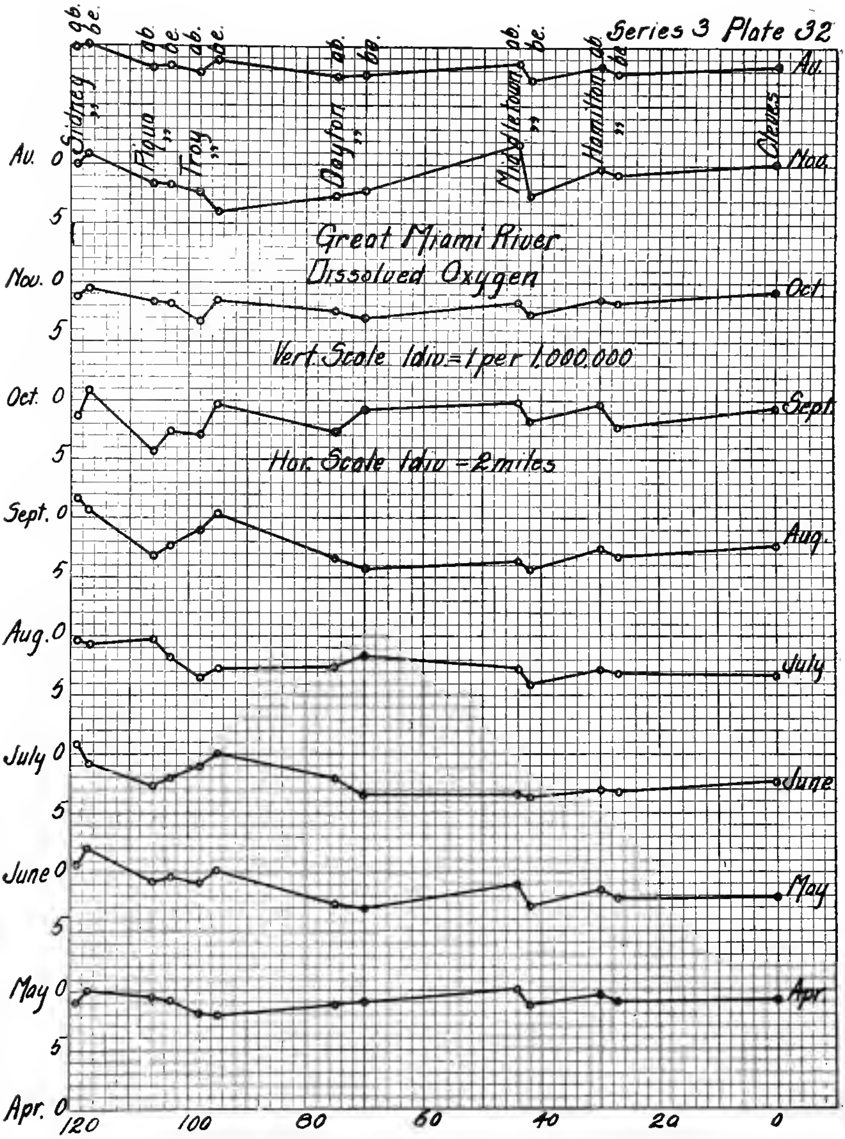
Series 3 Plate 28

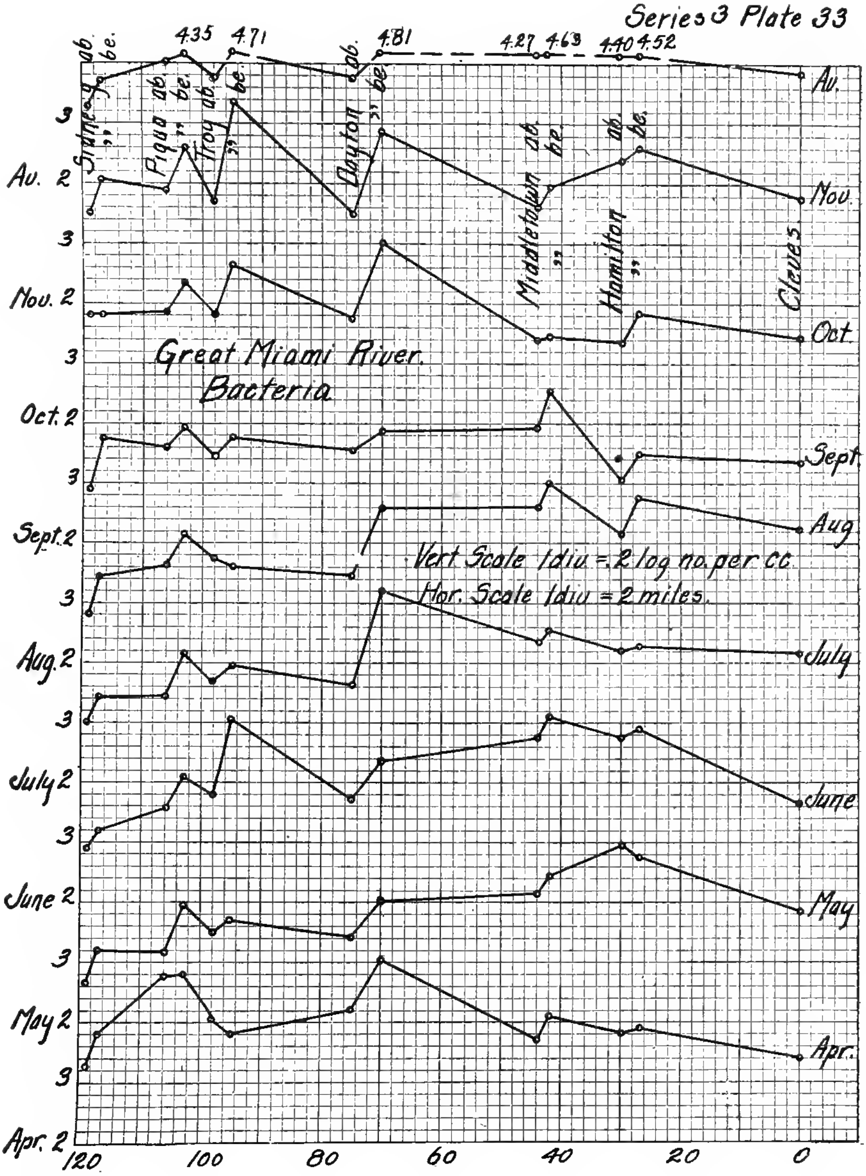



Series 3 Plate 29
Great Miami River.
Alkalinity
Vert. Scale 1 div. = 20 per 1,000,000
Hor. Scale 1 div. = 2 miles
Sidney
Piqua ab.
be.
Troy ab.
be.
Dayton ab.
be.
Middletown ab.
be.
Hamilton ab.
be.
Cleves
Ave.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
200
Av. 100
200
Nov 100
200
Oct. 100
200
Sept. 100
200
Aug. 100
200
July 100
200
June 100
200
May 100
200
Apr. 100
120
100
80
60
40
20
0


Series 3 Plate 30
Great Miami River.
Incrusting Constituents.
Vert Scale 1 div.=20 per 1,000,000
Hor Scale 1 div.=2 miles
Sidney ab.
" be.
Piqua ab.
" be.
Troy ab.
" be.
Dayton ab.
" be.
Middletown ab.
" be.
Hamilton ab.
" be.
Cleves
Av. 0
100
Nov. 0
100
Oct. 0
100
Sept. 0
100
Aug. 0
100
July 0
100
June 0
100
May 0
100
Apr. 0
Av.
Nov.
Oct.
Sept.
Aug.
July
June
May
April
120
100
80
60
40
20
0


Series 3 Plate 31
Sidney ab.
" be.
Piqua ab.
" be.
Troy ab.
" be
Dayton ab.
" be.
Middletown ab.
" be.
Hamilton ab.
" be.
Cleves
GREAT MIAMI RIVER
Total Solids.
Vert. Scale 1 div. = 50 per 1,000,000
Hor. Scale 1 div. = 2 miles
Av. 300
550
Nov. 300
550
Oct. 300
550
Sept. 300
550
Aug. 300
550
July 300
550
June 300
550
May 300
550
Apr. 300
Ave
Nov
July
Oct.
Sept
Aug.
May
June
Apr.
120
100
80
60
40
20
0


Series 3 Plate 32
Sidney ob.
" be.
Piqua ob.
" be.
Troy ob.
" be.
Dayton ob.
" be.
Middletown ob.
" be.
Hamilton ob.
" be.
Cheves
Great Miami River
Dissolved Oxygen
Vert. Scale 1 div. = 1 per 1,000,000
Hor. Scale 1 div. = 2 miles
Au. 0
5
Nov. 0
5
Oct. 0
5
Sept. 0
5
Aug. 0
5
July 0
5
June 0
5
May 0
5
Apr. 0
Au.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
120
100
80
60
40
20
0


Series 3 Plate 33
Great Miami River.
Bacteria
Vert Scale 1div = .2 log no. per cc.
Hor. Scale 1div = 2 miles.
Sidney ab.
be.
Piqua ab.
be.
Troy ab.
be.
Dayton ab.
be.
Middletown ab.
be.
Hamilton ab.
be.
Cleves
4.35
4.71
4.81
4.27
4.63
4.40
4.52
Av.
Nov.
Oct.
Sept.
Aug.
July
June
May
Apr.
3
Av. 2
3
Nov. 2
3
Oct. 2
3
Sept. 2
3
Aug. 2
3
July 2
3
June 2
3
May 2
3
Apr. 2
120
100
80
60
40
20
0

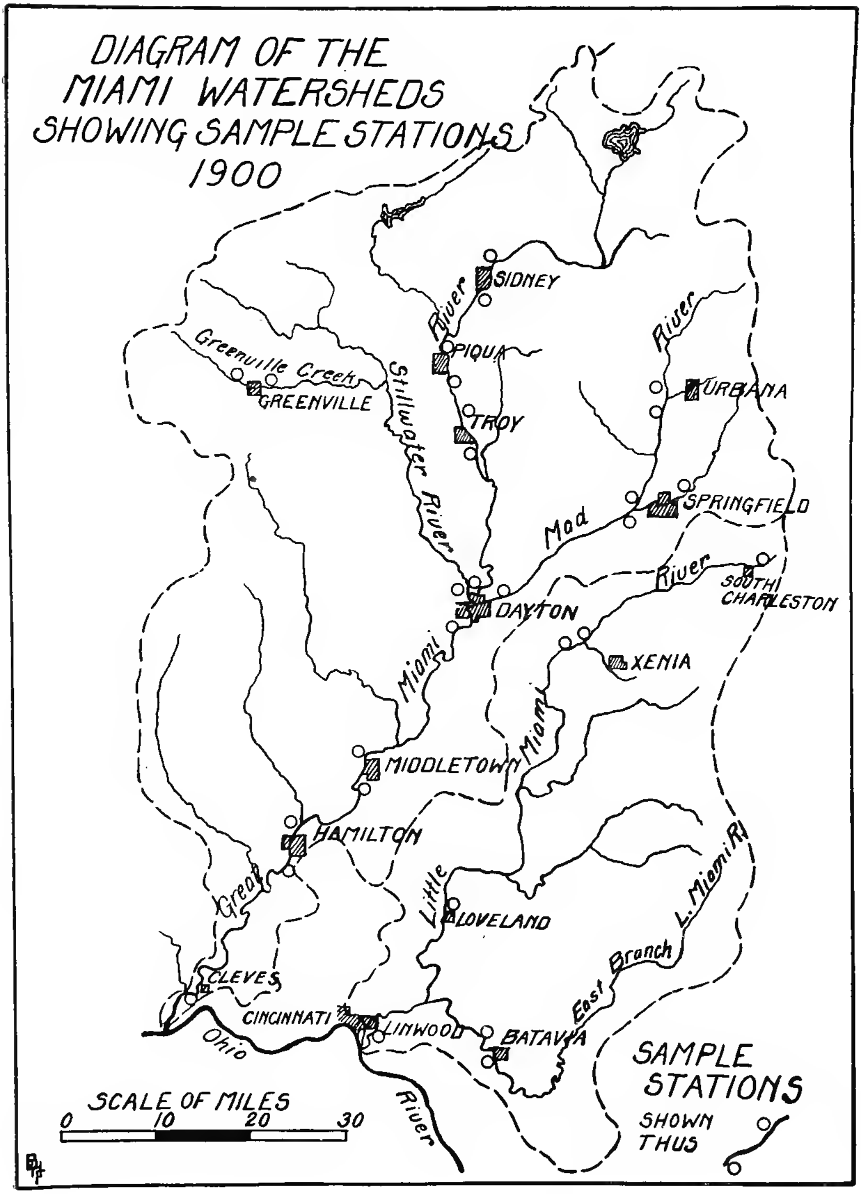


DIAGRAM OF THE
MIAMI WATERSHEDS
SHOWING SAMPLE STATIONS
1900
SIDNEY
River
PIQUA
TROY
River
URBANA
Greenville Creek
GREENVILLE
Stillwater River
Mad
SPRINGFIELD
River
SOUTH CHARLESTON
DAYTON
Miami
XENIA
Miami
MIDDLETOWN
HAMILTON
Great
Little
LOVELAND
L. Miami R.
East Branch
CLEVES
CINCINNATI
LINWOOD
BATAVIA
Ohio
River
SAMPLE STATIONS SHOWN THUS
SCALE OF MILES
0
10
20
30

VIII. DISCUSSION OF ANALYTICAL RESULTS.

1. LITTLE MIAMI RIVER.

Seven sampling places were made on this stream and located as follows: Above South Charleston on one of the headwater branches; above Xenia, below Xenia, above Loveland, and opposite Linwood; all on the main stream, and above and below Batavia on the East Fork of Little Miami River. This fork empties into the main stream some ten miles above Linwood. The South Charleston station was not established in April, and no September sample was taken there as the stream was dry except for a few pools.

Physical Properties. The waters of the Little Miami River presented rather inferior results in regard to appearance. The majority of the samples contained a considerable sediment, and while only a few (from the lower portion of the watershed) showed high turbidities, yet none of the samples were clear. In only one sample could the wire of the turbidity stick be seen at a depth of more than 10 inches. The waters always possessed a noticeable odor, and this odor was of a vegetative nature in most cases. The waters of the Little Miami occupy an intermediate position among the river waters of the state as regards color. The upper waters of the watershed were found slightly more colored than those nearer the mouth of the river.

Oxygen Required and Albuminoid Ammonia. Plates 1 and 2. These determinations are considered together as their fluctuations in the Little Miami are due chiefly to the vegetative organic matter in the water and not to sewage. The oxygen required and the nitrogen as albuminoid ammonia were nearly always high, indicating a large amount of vegetative material. The lowest findings were obtained at Loveland and Linwood. On the other hand the May and July findings at the latter place were the highest found for the season on this river, and were the result of heavy rains. The tributaries at Linwood in May and July were also extraordinarily high. It is to be noted that the rainfalls and the dates of sampling happened to stand in such relation to each other as to cause marked results to appear only at Linwood.

The generally high findings at Batavia show a goodly amount of vegetative matter in the East Fork, and indicate the wisdom shown in filtering the water of that branch before it is used for the public supply of the village named. This undesirable vegetation, as well as suspended silt and clay, is readily removed by a proper filtration.

The findings above Xenia in July indicate a slightly larger proportion of vegetative matter than usual. That the oxygen requirement and albuminoid ammonia findings were not still higher each month above Xenia, on account of the effluent from the strawboard factory at Cedarville, is doubtless due to the fact that, after leaving the reservoir, the effluent has a flow of several miles in Massick's Creek and then enter the main stream some distance above Xenia, and therefore the above determinations are reduced by oxidation, precipitation, and dilution to the point shown.

At South Charleston the river is a mere brook and for some distance above the sampling place, as was subsequently learned, it is overhung with weeds and grass while it slowly finds its way through fields and pasture land. It is therefore not strange that these determinations were found to be high at this place.

Nitrogen as Free Ammonia. Plate 3. The absence of marked sewage pollutions is shown by these curves. The sewage from the Clermont County Infirmary causes a small increase in free ammonia below Batavia. A considerable amount of free ammonia was present at South Charleston and at first thought it might be attributed to barnyard drainage, but the chlorine does not correspond, and the cause rests in the local pollution along the banks above the sampling place.

At Xenia the water above the town is ordinarily high enough in free ammonia to fail to be increased by the water from Shawnee Run. The city of Xenia is but little sewered and so Shawnee Run carries but little sewage, although some is present as shown by the various findings.

Agreeing with the chlorine findings there is a slight increase in the nitrogen and free ammonia between Loveland and Linwood.

Nitrogen as Nitrites and Nitrates. Plates 4 and 5. As usual the lowest findings were obtained during the dry weather months toward fall. The results indicate no great past pollution which had not been overcome, and this is especially true of the East Fork water at Batavia. In the earlier months of the investigation the results on the main stream were higher as a result doubtless of farm drainage during cultivation, since manures and soil enrichers are used in this section of highly cultivated land.

The general high nitrites at Xenia are attributable not to that city alone, but have their source in material introduced farther up stream, partially at the Cedarville strawboard factory and partly from other sources.

Chlorine. Plate 6. These curves serve as the best indicators of sewage influences on the stream, since the chlorine was less disturbed by local factors than the determinations for nitrogen, for oxygen required, and for bacteria. The general low chlorine findings show the absence of specific sewage pollutions as well as of the decided mineral pollutions which have been recorded in some of the previous investigations of the streams of the state. The maximum chlorine averages for the season on the Little Miami were at Linwood and below Xenia, each being 2.3 parts per million. As might be expected the chlorides were generally higher in the fall months when the volume of water in the river was least.

The slight sewage influence of Xenia is shown by the rise in each curve at the point representing the entrance into the Little Miami River of Shawnee Run, which carries the sewage of the city. By reference to the accompanying report of the Engineer of the Board it is seen that, aside from the Ohio Soldiers and Sailors Orphans' Home, a very small proportion of the people of Xenia have access to the sewers, and consequently a much smaller sewage influence is exerted on the stream by that city than one might think if only the number of inhabitants were considerd. The sewage from the Home is not supposed to reach the river by way of Shawnee Run except in occasional instances.

The slight increase in chlorides at Batavia is indicative of a small amount of sewage from the County Infirmary plus some surface drainage from the village. It is noticed that the chlorine findings above and below Batavia are much higher in April, October and November than during the summer months. This peculiarity may be somewhat influenced by the wintering of a large number of steers on the bank of the river above Batavia at the town of Lynchburg. (See Engineer's report under Lynchburg.) The steers begin to arrive early in October and are sold in the spring. Owing to the crooked course of the stream, Lynchburg is nearly fifty miles from Batavia by river, and organic matter has opportunity to be disposed of but the chlorides remain.

At South Charleston the stream usually contains little or no chlorine, but departures occurred in July and November. Such departures in a stream of moderate size might mean something, but in so small a branch of quiet flow as the one at South Charleston a minor local factor could produce distinct changes in the analytical figures.

The diluting effect of the heavy rains is seen in the May and August samples at Loveland and Linwood, and again at the latter place in July.

Alkalinity and *Incrusting Constituents.* Plates 7 and 8. The amounts of incrusting material were fairly constant throughout the Little Miami River and were lower than for any of the streams of the state previously studied. The head waters were more alkaline than those of the southern portion of the watershed, as shown by the general dip of the curves from left to right. Although the southern samples were somewhat more influenced by rainfalls than the northern samples, yet it remains true that the northern area yields the harder waters. The waters of East Fork were lower in alkalinity than those of the main stream, the averages for above and below Batavia being 135.1 and 139.5 respectively, while the averages on the main stream varied from 167.8 at Linwood to 249.1 above Xenia.

As Batavia has recently (October, 1900) installed a public water supply, using the river water after mechanical filtration, and as their process of treatment involves the use of a coagulant, it is well to consider the alkalinity obtained above Batavia. The coagulant is decomposed by the carbonates and bi-carbonates and hence there should not be too low an alkalinity otherwise undecomposed coagulant might appear in the effluent —a condition which should not occur. The lowest alkalinity above Batavia was 80.0 (obtained in high water) and this figure gives a good margin of safety for the proper and intelligent operation of the filter plant.

Diluting influences from rainfalls are best seen at Linwood in May, July and August.

Total Solids. Plate 9. The solids were rather lower than usual for Ohio streams and were fairly constant throughout the watershed barring the excessive amounts of clay borne in the high waters at certain sampling periods. As stated in the previous section the head waters were slightly harder, but this was compensated for, as regards total solids, by the increased amounts of suspended matter in the water of the lower portion of the watershed. Agreeing with the hardness the solids of the East Fork were lower than those obtained on the Little Miami River proper.

Dissolved Oxygen. Plate 10. These curves by the dips at Xenia and Batavia show the addition of some organic matter. Some rather low results were obtained at South Charleston when the water was low. On the whole the results for the stream are low indicating an amount of oxygen below the normal.

Bacteria. Plate 11. In general the bacterial results agree with other findings in showing a slight sewage influence below Batavia. On the other hand, while some sewage enters the river between the two sampling places at Xenia, its presence is not indicated by the course of the bacterial curves. This is an unusual occurrence and is due to the abnormally high number of bacteria at the sampling place above Xenia. In considering the effect of the strawboard factory refuse introduced at Cedarville, and which caused the bacterial disturbance just referred to, we noticed here, as in other streams where similar conditions existed, that on the mixture of strawboard factory wastes with river water a great increase in the number of bacteria occurred, and further that this high bacterial content of the stream persisted longer than the chemical evidences of the specific pollution. It appears that microbic life finds under those conditions a favorable environment and hence propagation of certain species rapidly ensues.

The findings at South Charleston are higher than might at first be expected, but they agree with the other results in indicating considerable organic matter, and in addition it should be noted that all the samples at this station save one, were affected by local rains. The low finding at Xenia in July is responsible for the downward course of the curve from South Charleston.

The relatively low number of bacteria at Xenia in June, July and September give an intimation of what might be expected with cessation of the specific pollution from the strawboard factory at Cedarville. The high number of bacteria in the remaining months at Xenia is due to this pollution and is not indicative of sewage or the usual effect of surface washing.

The May samples exhibit the most uniform rain influences on the stream, while the July result at Linwood produces the greatest inflection in the bacterial curves due to precipitation causes.

The stream as a whole is rich in microbic life—especially so, for so small an amount of sanitary sewage. In one sample above Batavia there were 750 bacteria per c. c., but the next lowest finding in the 52 samples bacterially examined was 1200 bacteria per c. c. In 75 per cent. of the samples there were upward of 2,000 bacteria to c. c.

SUMMARY FOR LITTLE MIAMI WATERSHED.

The average composition of the water of the Little Miami River including the East Fork is as follows computed from the averages at our seven stations:

Color	.29	Chlorine	1.6
Turbidity	.52	Alkalinity	197.8
Oxygen required	6.32	Incrusting constituents	15.
N. as albuminoid ammonia	.329	Total solids	387.
N. as free ammonia	.100	Dissolved oxygen	7.86
N. as nitrites	.018	Bacteria per c. c.	23900.
N. as nitrates	.27		

The station established at South Charleston to determine the purity of the headwaters was of little value as the samples there happened to be too much influenced by local rains, in addition to local pollutions which greatly affected so small a stream. The grossest pollutions occur at or near the headwaters and hence the question is, "Does the water attain a reasonable degree of purification?" On the main stream the best water is in the lower course and is possibly as good above Loveland as anywhere, and yet its character is not such at that place as would entitle it to consideration for a public water supply without treatment of some nature.

The accompanying report of the Engineer of the Board says that the conditions at Lynchburg are very bad in the winter, but with the cause of the trouble removed in the spring the evil effects on the stream are lessened. The analysis at Batavia show that from April to November the Lynchburg pollution had been well purified by the time the water reached the first named village. Batavia has just introduced a public water supply, taking the water from the river and treating it by mechanical filtration, thus adding artificial to natural methods of purification in the securing of a water of good qualiy.

With the water of the East Fork of the Little Miami River possessing some desirable features as shown by our analyses, and with the undesirable characters removed by the proper operation of their filter, the citizens of Batavia should be supplied with a very acceptable water and one whose use for domestic purposes should, from a sanitary standpoint, quickly supplant the waters derived from private wells in the village.

In regard to the suspended matter the Little Miami is worthy of mention, for the results obtained during 1900 indicate that its waters are seldom clear under ordinary conditions of weather, and at times of rain it becomes a turbid stream and exceedingly so in the southern portion.

As a whole the Little Miami River is comparatively free from sanitary sewage, but it receives manufacturing sewage, and contains so much organic matter of a vegetable nature, especially in its upper waters, that purification is somewhat retarded, and would be more so with grosser pollutions. Accordingly the Little Miami River does not rank well among streams as regards ability to care for pollutions by natural purification. On this account it is well that the sewage of Xenia (which city is about to be sewered) is to be filtered before it is emptied into Shawnee Run a short distance above the point where that tributary enters the main stream.

Sampling stations were not established on Massick's Creek, but when the writer saw that stream in June its condition was foul. Bubbles of gas were rising to the surface of the liquid and a test showed the entire absence of dissolved oxygen. As is stated in the Engineer's report Massick's Creek is but little more than an open sewer, by which a little surface drainage from Cedarville and a larger amount of strawboard factory drainage reach the Little Miami River.

As regards hardness the waters of the Little Miami occupy an intermediate position in Ohio, though perhaps no softer than the average. Some other streams have shown lower alkalinities but none thus far studied have been lower in amount of scale forming material, and with the suspended matters removed these waters could be used for boiler purposes, although sludge would form and need to be removed..

2. GREAT MIAMI WATERSHED.

This portion of the work will be considered in three divisions, viz: Stillwater River including Greenville Creek, Mad River including Buck or Lagonda Creek, and the Great Miami River proper.

a. STILLWATER RIVER.

There were three sampling places on this portion of the Great Miami, two being located near Greenville on the creek bearing that name, the upper one above town and opposite the water works, the other below town. The third station was on Stillwater River, a short distance above its mouth.

Physical Properties. In color the samples were quite uniform. None of the samples were free from suspended matter as all deposited noticeable amounts of sediment and about 30 per cent. of the samples showed considerable sediment, but they did not carry the large amounts of clay found elsewhere on the Great Miami system. The highest turbidities from the Stillwater basin were found at Dayton in April and at Greenville in October, both being caused by recent sharp rains. The April sample below Greenville was taken shortly after the commencement of a heavy rain, but insufficient time had elapsed to allow much of an increase in turbidity. Doubtless turbidities greater than .40 do occur at times but they are of short duration in a stream like this, and a further study of the rainfall table, the dates of sampling, the local conditions, and the turbidities obtained indicate that this tributary does not attain excessive turbidities. However, the results indicate that the waters of the Stillwater basin do not become extra clear under ordinary conditions. The lowest finding was at the Greenville station in November when no rain had fallen for ten days, but even then after a dry period in a dry fall the turbidity wire was visible only at a depth of twelve and one-half inches.

Most of the samples had a vegetative or earthy odor while none were odorless.

Organic matter as indicated by findings for *oxygen required* and for *nitrogen as albuminoid ammonia, free ammonia, nitrites, and nitrates.* Plates 12-16.

It is seldom that the effects of surface washing after rains are so well shown as in the Stillwater curves and determinations for the oxygen requirement. This is due in part to the otherwise minor departures from the normal. Excessively large amounts of carbonaceous matter are not met with at any time, but the direct rain influences are noted at Dayton and also in a lesser degree at the station below Greenville in April, and again at both Greenville stations in October. The July and September curves had upward tendencies as the result of minor additions from rainfalls at Dayton and their absence at Greenville.

The albuminoid ammonia results give in a slightly lessened degree the same indications as do those just discussed. The ammonias are higher than in some of the better streams, but the rise in these curves as well as in those for nitrites and oxygen required point to the addition of some sewage at Greenville. In August most of the curves descend at Greenville owing to some unusual pollution above the city. This was not found again.

All the nitrites at Greenville were high save in November, and they had not disappeared in Dayton except in October, although nearly so in July. The upward course of the nitrite curve between the Greenville stations was reversed in May, July and October, due to the unusually high readings above town. The nitrites of the stream were generally high for an open watercourse which was not receiving grosser pollutions, and they indicate incompleteness of purification. In general the nitrates show the usual seasonal variation, but the higher figures of the late fall are wanting as cold rains had not yet commenced. Nitrates were quite in evidence in the spring but decreased in the late summer and early fall to a minimum period. Why the nitrates in the June and November samples were high at Dayton and low at Greenville, with the reverse condition in May is not quite understood.

Chlorine. Plate 17. The full extent of Greenville's influence upon the waters of Greenville Creek is shown better in the curves for chlorine than in the free ammonia of other curves. Two causes lead to this. First, chlorides are almost wanting in the water above the village under ordinary circumstances while considerable free ammonia is present with vegetative organic matter. Second, the indirect influence from Greenville either by seepage or by direct surface drainage would contain its proportion of chlorine unchanged, while the organic matter by filtration and oxidation would have passed beyond the first steps of decay. After the rise at Greenville the chlorine curves show distinct drops due to dilution, except for October. Here it should be noted that the Greenville samples for the month named were affected by rainfall and the chlorides accordingly lowered, while the Dayton October sample was not so affected, and in addition it, for some reason not apparent, yielded the highest chlorine finding of the season for that station. Although the chlorine curve for August shows the usual upward tendency at Greenville yet attention is called to the high results then obtained at the upper station for chlorine, oxygen required, albuminoid and free ammonias. The dissolved oxygen in that sample was also high. This pollution occurring but the one time does not disclose to us its source.

The mineral characters of these waters are well shown by the findings for *alkalinity, incrusting constituents,* and *total solids,* (Plates 18-20), in addition to the sections just given. Due to the absence in these samples of the marked quantities of clay and silt obtained in most of the preceding investigation, the curves for solids agree better with those for alkalinity and incrusting constituents. In addition to carrying only small amounts of suspended matter, the Stillwater samples were noticeable for their lack of sulphates—being nearly as low in incrusting material as the water of the Little Miami River. The Stillwater samples, however, were not lacking in carbonates or bi-carbonates, as shown by the high alkalinities. The discrepancy in the direction of the April and October curves for solids compared with the actual mineral character of the waters was due to the local rains at those times at Dayton and Greenville, as already referred to.

In general the mineral character and total solids of the stream increase slightly at Greenville and then decrease much more by dilution with softer waters before Dayton is reached.

Bacteria. Plate 22. It is to be noted that none of the samples from Greenville Creek or Stillwater River were low in bacterial life for the best finding was at Dayton in May when 1000 bacteria were present in a cubic centimeter of the water and two-thirds of the samples taken had 2,000 or more bacteria per c. c. The indications are that the October result at Dayton was due to an accidental contamination, and it should not be taken as representative. The April findings at the two lower stations were augmented by the sharp rainfall at or before the time of collection. The slight downward course of the October curve at Greenville has no significance, since the bacterial content of both samples had been so far removed from normal by rain influences as to lose whatever value they might otherwise have possessed as indicators of sewage. The remaining curves by their course at Greenville show the increase in bacteria resulting from the direct and indirect pollutions of the creek between the stations above and below Greenville.

SUMMARY FOR STILLWATER RIVER.

When uninfluenced by rains the water of this tributary is quite uniform in character, and when influenced by rains there is not the extreme variation that frequently appears elsewhere. This stream is moderately rich in vegetative matter but lower than some. Its quality is not such as would make it an acceptable source for a public supply if the raw water was used. Although the present Greenville water supply has some undesirable mineral characters, yet it is decidedly preferable to the raw water of Greenville Creek from a sanitary view.

Although the water above Dayton is on the whole somewhat better than that found above Greenville, yet the results indicate that purification is rather tardy and it may be found necessary for the sewage of Greenville to be treated before it is emptied into the river.

The average composition of the water as found in Greenville Creek and Stillwater River is as follows, the October bacterial finding at Dayton having been omitted as an unreliable one.

Color	.25	Chlorine	1.4
Turbidity	.17	Alkalinity	239.8
Oxygen required	4.79	Incrusting constituents	23.7
N. as albuminoid ammonia	.245	Total solids	427.
N. as free ammonia	.068	Loss on ignition	140.
N. as nitrites	.016	Dissolved oxygen	8.96
N. as nitrates	1.42	Bacteria per c. c.	7727

b. MAD RIVER.

The graphical representations of these results appear in curve "B" In order to permit "B" and "C" to be placed on the same plate, ten miles were omitted from curve "B" between Springfield and Dayton. Six stations were established on this division of the Great Miami watershed. The uppermost station was above Urbana; the next one was below Urbana and nearly a mile below the mouth of Dugan Creek, which branch bears a little sanitary sewage from Urbana and a considerable amount of strawboard factory waste. The third station was on Mad River above Springfield and just above the mouth of Lagonda or Buck Creek, which stream carries most of the sewage from the city of Springfield. The station which appears third on the plates, owing to its greater distance from the mouth of the Great Miami River, is the one above Springfield on Buck Creek. The last named station was opposite the present pumping station of the Springfield water works and at the point where a pipe enters Buck Creek to serve as a supplementary source for the supply of Springfield. The fifth station was on Mad River below Springfield and in order to include the pollution from the factories near that city had to be located some distance below the mouth of Buck Creek. The sixth station was on Mad River at Dayton and opposite Harshmanville.

Physical Properties. The main tributary of Mad River, viz: Buck Creek, possesses better physical properties than many of the Ohio streams but it is by no means to be thought of as a perfect water in this respect. The most notable change in color in the water of Mad River occurs as the result of the addition of strawboard factory refuse at Urbana. Taking the average above Urbana as a standard for Mad River, there is found such an increased color below Urbana that the average color at each station on Mad River proper remains higher than the standard until Dayton is reached, in spite of successive dilution.

Like the samples from the Stillwater watershed, those from Mad River fail to show great increases in turbidity after rains, for omitting the station below Urbana where the turbidity was modified by the strawboard effluent, we find the greatest turbidity for the season was above Urbana in September when the reading was only .38. Besides failing to become very roilly, it seems the water of Mad River quickly recovers from a changed turbidity as shown by the low findings of the May samples —preceded a few days by one of the hardest rains falling on this part of the watershed during the time of our studies. On the other hand the results from the Mad River basin indicate waters that are seldom really clear under ordinary conditions, for of forty-eight samples only three (two on Buck Creek and one on Mad River above Urbana) were clear enough to enable the wire of the turbidity stick to be seen beyond a depth of fourteen inches. In the three exceptions the wire was visible at a depth of 20 inches, which in one case was the depth of the water. In spite of the moderately low turbidities it is to be noted that an unusually large number of the samples—more than half—showed a "considerable" sediment. This would indicate the suspended matter was of the nature of vegetation, loam and sand rather than clay in its finely divided state. None of the samples were odorless except two from Buck Creek, while many showed by the odor their vegetable character.

Oxygen Required and Albuminoid Ammonia. Plates 12 and 13. As indicators of sewage these determinations were of little value in Mad River owing to the disturbances caused by pollution of anothe rnature, but as indicators of the pollution from the strawboard factory they take high rank. The marked jumps taken by these curves at Urbana suggest a strong influence but the other findings and the facts show that only a very small amount of sanitary sewage enters the river from Urbana. The fluctuations at Urbana are due to the presence of greater or less amounts of factory wastes. The April and July curves are flatter than the others, the former because of dilution from rainfall, the latter because of a diminished amount of the factory refuse.

The amount of carbonaceous organic matter in Mad River was greater below Springfield than above only in May. Two factors helped to produce this result. One is the entrance of the water of Buck Creek between the sampling points; the other is the presence of so much undecomposed material from the Urbana pollution as to cause the water of Mad River above Springfield to still be high in albuminoid ammonia and oxygen required. When the pollution below Urbana rose, the findings at Springfield were also higher, showing too great a pollution for the stream to handle in that distance and regain its normal purity. By a comparison of the results above Urbana with those above Dayton it is seen that in a flow of some forty-five miles sufficient purification and dilution had occurred to counterbalance the pollutions of Urbana and Springfield as judged by the findings for oxygen required and albuminoid ammonia. In connection with this, reference may be made to the findings and the curves (Plate 21) for dissolved oxygen. The amount of free oxygen was of course lowest below Urbana because of the strawboard factory refuse, and did not regain its normal until the above Dayton sampling place was reached. The results above Springfield on Buck Creek show a higher proportion of free oxygen.

The *Nitrites* (Plate 15) mark the pollution at Urbana, the flattened curves for April, July and October, being partially due to rain influences, and in part especially in July to a lessened pollution at Urbana. The nitrites agree with the free ammonia, chlorine and bacteria in showing the addition of sanitary sewage at Springfield. In general the nitrite findings above Dayton were but a trifle higher than those in Buck Creek above Springfield, and in Mad River above Urbana, indicating a fairly good degree of purification by the time the water reached Dayton.

Nitrates. Plate 16. Little comment is necessary here. The results on Buck Creek were generally a little higher than elsewhere. The November result above Dayton is not attributable to surface washings and its cause is not apparent.

Free Ammonia and Chlorine. Plates 14 and 17. These may be discussed together since they are for this stream the best indicators of the extent of sewage pollution. The only free ammonia curve failing to rise after the addition of Springfield's sewage was the one in June, when the finding above town was one-third higher than in any other month. This high reading as well as the somewhat lower, though still high ones for July and September, did not come from fresh sewage. The chlorines do not follow the three ammonia determinations just mentioned nor again in August below Urbana, when the chlorine curve takes an anomolous turn upward. In the latter case the water was unusually rich in oxygen consuming power at the time and a possible source for the chlorine may have been the muriatic acid, used at times in the process of making strawboard. The chlorine falls slightly from Springfield to Dayton with the dilution which is small in that stretch of the stream's flow. The amount of free ammonia above Dayton was moderately low except under the influence of the April surface washings, and was as low as that above Springfield on Buck Creek, or above Urbana on Mad River and shows a return to original conditions after the pollutions which exist on this stream and tributaries.

The *Incrusting Constituents* (Plate 19) are generally low, but what appears unusual is their increase on the addition of surface washings.

The *Alkalinities* (Plate 18) are very high throughout. Except in April, when the water was high as noted by the collector, there occurs a marked increase in alkalinity below Urbana which is lost, however, by the time the water reaches the Dayton station. The water of Buck Creek is slightly richer in sulphates and poorer in carbonates than is the main stream, but in connection with the sewage of Springfield it affects the mineral nature of Mad River very little.

Since the highest figure obtained for total solids was 535, it is observed that none of the results for solids were unusual.

Bacteria. Plate 22. These findings and resulting curves show well the bacterial effects of the two major pollutions of Mad River, viz: the strawboard effluent at Urbana and the Springfield sewage. At each of these cities the curve exhibits a decided rise every time. The greater inflection was at Urbana, but of course the latter would constitute the more serious menace to health owing to the opportunity for the presence of pathogenic bacteria. Furthermore the strawboard refuse produces the more marked and more persistent disturbance of the physical properties of the water, and the appearance of a water receiving strawboard refuse would prevent the ordinary person from using it as a beverage where a sewage polluted water might be unhesitatingly accepted by that person because its appearance was not bad and because it had a good taste.

In no month was the bacterial finding above Dayton as low as above Springfield on Buck Creek, and only in August, September and November did the findings at the former place remain lower than those obtained above Urbana. From the bacterial side the pollutions of the river are not compensated for by natural processes of purification. Here again we would note the persistingly high bacterial content of a river water which has received the refuse from a strawboard manufactory. The Buck Creek bacterial findings were not so bad for an open stream when used for water powers and commercial enterprises, but they are not wholly satisfactory for a water to be supplied for domestic purposes to a large and thriving city. Omitting the Buck Creek samples, the Mad River results were all high, as only five samples showed less than 2,000 bacteria per c. c., viz., 700 and 1,700 in May and June above Urbana, 1,400 in August above Springfield, and 1,500 and 1,700 in May and August above Dayton. The greatest disturbance by rain was in April at Urbana and at Dayton, but not at Springfield as the samples at the last named city were taken two days earlier, and thus previous to the rain which occurred during the sampling period. The minimum, maximum, and average bacterial findings per c. c. are given below arranged according to the minimums:

Station and Stream.	Minimum.	Maximum.	Average.
Springfield, above, Buck Creek	325	1,200	738
Urbana, above, Mad River	700	12,000	4,000
Springfield, above, Mad River	1,400	30,000	9,575
Dayton, above, Mad River	1,500	30,900	6,750
Springfield, below, Mad River	5,900	115,100	30,625
Urbana, below, Mad River	6,800	803,000	160,750

SUMMARY FOR MAD RIVER.

The average composition of the water of this stream including Buck Creek as determined by forty-eight samples from six stations is as follows.

Color	.26	Chlorine	1.4
Turbidity	.20	Alkalinity	262.2
Oxygen required	[a]9.24	Incrusting constituents	14.1
N. as albuminoid ammonia	[b].280	Total solids	430.
N. as free ammonia	[d].070	Loss on ignition	136.
N. as nitrites	[e].027	Dissolved oxygen	8.36
N. as nitrates	.85	Bacteria per c. c.	[c]35406

---

[a] Ninety-five per cent. higher than it would have been with the findings below Urbana omitted.

[b] Thirty-one per cent. higher than with findings below Urbana omitted.

[c] Two hundred and forty-two per cent. higher than with findings below Urbana omitted.

[d] Sixty-nine per cent. higher than with findings below Springfield omitted.

[e] Eighty-six per cent. higher than with findings from below Springfield and below Urbana omitted.

An interesting study is found in the foregoing table and the reference to the increases which occurred over what the average would have been in certain cases with the omission of the results below Urbana (so modified by strawboard factory refuse) or those below Springfield (modified by sewage).

If it were not for the marked pollution at Urbana and Springfield the waters of Mad River would be fair waters as regards organic material. The studies indicate in this stream a greater ability for self purification than in some cases. The water at Dayton compares favorably in most respects except as to the number of bacteria with the headwaters. The physical properties are included within moderate limits except for the addition of material from Dugan Creek at Urbana. Unlike some waters studied the present one will on a short sedimentation deposit most of its suspended matter although some fine material will remain in suspension for a considerable time. The best water of this system as far as our investigations were carried was found in Buck Creek, but as indicated in various places in preceding tables, curves, and discussion, the water of Buck Creek does not possess a sufficiently high degree of purity to make it a wholly acceptable source of supply in the raw state for the city of Springfield.

C. GREAT MIAMI RIVER.

Thirteen stations are located on the Great Miami River proper, one station above and another below each of the following six cities: Sidney, Piqua, Troy, Dayton, Middletown and Hamilton, while the thirteenth station was below Cleves. The April sample at the last named place was taken below the mouth of Whitewater River, but the remaining collections were made above the point where that tributary empties. For further details as to location of sampling points the reader is referred to a previous section of this report. Attention is again called to the fact that it was necessary for the collector to make two trips owing to the number of stations, and consequently the samples at Middletown, Hamilton and Cleves were collected from five to fourteen days later in the month than those at Dayton and points farther north. During the following discussion the stations or samples referred to as *southern* are those at Cleves, Hamilton, and Middletown; while those at Dayton, Troy, Piqua and Sidney are spoken of as *northern* stations or northern samples.

Physical Properties. The color of the water was moderate in amount and fairly uniform throughout the stream and season. The highest average was .29 obtained below Middletown.

At most of the stations the prevailing odor was vegetative or at times earthy, but below the larger places, as Hamilton, Middletown, Dayton, Troy and Piqua the odor was stronger and less pleasing. In regard to the amounts of suspended matter considerable difference is noted between the northern and southern samples, because the former were influenced but little by rainfall except at Piqua in April, while the samples from the southern section usually gave evidence of present or recent rains. The April sampling period for the northern route was one of general rains, but Piqua being the last city visited on the trip showed the greatest influence from surface washings. In consequence of the presence of heavy surface washings in the waters of the southern section some excessive turbidities were obtained. In none of the investigations previous to this year have such high readings been obtained, and that the total solids were not higher in the cases of these abnormal turbidities indicates the presence of a very fine clay, and not suspended material of a heavier nature.

Seventy per cent. of the southern samples had "considerable" or "much" sediment while the clearest sample had a turbidity of .09. In support of these roilly findings in the lower course of the Great Miami River we would make mention of a statement made to the collector by a resident of Cleves who said he had lived in Cleves seven years and did not remember seeing the water of the stream what could really be called clear.

Oxygen Required. Plate 23. *Albuminoid Ammonia.* Plate 24. The most noticeable additions of carbonaceous and nitrogenous matter by surface washings are shown at Piqua in April, and in the lower course of the stream in May, July, and also to a lesser degree in June. The curves of averages for these determinations also show the disturbances just noted. The unexpected jump upward from Middletown to Hamilton in May, when the samples from the two cities were taken within the space of three hours deserves explanation. There had been a heavy local rainfall on Seven Mile Creek. It waters enter the Great Miami above Hamilton and below Middletown. The July result at Cleves was also due to surface washings.

Some of the Piqua pollutions enter the canal and some water escapes at intervals from the canal to the river between Piqua and Troy. This helps keep up the various findings for organic matter above Troy. The general upward trend of the various curves at Middletown is not due alone to sanitary sewage for certain of the determinations for organic matter are greatly modified by the nature of the manufacturing sewage admitted. By reference to the report of the Engineer, it is seen that Middletown possesses a thriving paper mill industry.

The failure of the curves for the oxygen required and albuminoid ammonia to rise at Dayton with the addition of the sewage of that city is worthy of consideration. Between the two Dayton stations on the Great Miami River that stream receives the waters of its two largest tributaries, viz., Mad and Stillwater rivers. By reference to Table I. of the Engineer's report it is seen that the drainage areas of Mad and Stillwater rivers are respectively 645 and 653 square miles. No gagings are available to inform us of the relative volumes but with the drainage areas so nearly equal and with nearly the same monthly rainfall (except in September) it is permissible to assume the volumes of water in Mad River and Stillwater River at Dayton were approximately the same. With equal quantities of water in these tributaries the mean of their quantities would represent the character of the tributary water received at Dayton. Wolfe Creek may be considered one of the pollutions of Dayton. From the analytical tables the following figures are obtained:

	Oxygen Required.	Albuminoid Ammonia.
Average for Mad River at Dayton	3.87	.194
Average for Stillwater River at Dayton	4.50	.251
Mean of Mad and Stillwater Rivers at Dayton	4.18	.222
Average for Great Miami River above Dayton	5.90	.307
Average for Great Miami River below Dayton	5.46	.309

The drainage area of the Great Miami River above Dayton is 1158 square miles and that of the two tributaries is 1298 square miles. The rainfalls were on the whole similar. Without Dayton influence the average oxygen requirement below Dayton should have been close to 5.00 parts per million without additional purification, but the finding was 5.46 parts. In the same way the albuminoid ammonia below town would have been in the neighborhood of .262, whereas .309 parts were found. Therefore while a glance at the plates would cause one to think there had been no organic matter added at Dayton, a closer study shows there was such an addition which agrees with the facts as given in the Engineer's report.

The causes for the increased findings at Troy in September and November are not apparent. If the greater amounts of water had entered the river from the canal containing so much organic material, the oxygen required would also have been higher.

Nitrogen as Free Ammonia. Plate 25. The generally flat course of the curves shows the absence of such concentrated pollutions as were found below certain cities on watersheds previously studied. The averages show more or less of an increase between the above town 'and below town stations for each village or city where samples were taken.

Because of the relatively low amount of free ammonia in the water of Great Miami River above Dayton compared with the albuminoid and with the oxygen required, and because of the greater effect upon the free ammonia findings when sewage is introduced, we find the free ammonia curves rising below Dayton in spite of the diluting effects of Mad and Stillwater rivers as mentioned in the preceding section.

In connection with the distinct additions of free ammonia factors at a town no larger than Troy in comparison with larger places on the stream, reference should be made to the figures given in the Engineer's Table of Sewerage. While Troy is not one of the largest places on the stream yet it takes second rank among those on the Great Miami in the estimated per cent. of population using sewers, and in actual number of persons using sewers, only two places on the main stream (Dayton and Hamilton) make a higher showing. In addition to this relatively heavy sanitary sewage pollution, we should not fail to mention the refuse which reaches the river from the slaughter houses at the edge of Troy. The unusual result at the place just named in April may have had some connection with the heavy rainfall at the time of taking those samples. Similar fluctuations for chlorine and nitrates appear but not for albuminoid ammonia and oxygen required.

In September at Hamilton the water was low and the below town finding was greater than at any other time in the season—causing a greater inflection in the curve.

Nitrogen as Nitrites and Nitrates. Plate 26 and 27. The nitrites, and to a lesser degree the nitrates, show the effect of urban pollutions.

Like the free ammonia the nitrites show more prominently than the oxygen requirement and the albuminoid ammonia the pollution from Dayton.

The April nitrates at Piqua are in evidence because of the effect of the rainfall influencing those samples so much more than the others as previously noted. The curve's jump at Dayton in November is not attributed alone to the Great Miami nor to Dayton as the samples at Dayton on Mad River and Stillwater River were also high.

Chlorine. Plate 28. As indicators of urban pollution these findings need little comment—the curves speak for themselves as they show the addition of sewage at each town and city. The chlorine curves at Dayton are not misleading as were those from some of the other determinations since the chlorine was less influenced by other causes. April yielded the flattest curve for the samples were all under some rainfall influence. In September the southern samples were taken under drier conditions and the lack of dilution is apparent in the higher level of that portion of the September curve. The drops from below Middletown to above Hamilton in May and July are not customary and they were occasioned by the decidedly greater amounts of rainwater at the latter place. This influx of rainwater was chiefly from Seven Mile Creek where heavy rains had occurred. The extent of these peculiar rain changes may be illustrated by a comparison of turbidities although the Hamilton sample was taken within two hours of the one below Middletown. In May the turbidity below Middletown was .16 and above Hamilton 5.60; in July the turbidity below Middletown was .54 and above Hamilton 2.45. The determinations for oxygen required and albuminoid ammonia also show the same changes.

Alkalinity and Incrusting Constituents. Plates 29 and 30. As shown by the findings and the curves for averages the waters of this stream were fairly uniform in these characters. The carbonates were very high but the sulphates and chlorides were low and thus while the water at any place is hard yet the hardness is chiefly temporary and thus better than in some of the streams of Ohio. Two breaks are noticeable on the alkalinity plate due to rain influences in April and May.

Total Solids. Plate 31. Agreeing in general with the combined alkalinity and incrusting constituents the solids showed no marked departure from the normal except when heavy rains caused the waters to contain larger proportions of soil as at Piqua in April, at Hamilton in May, and at Cleves in May and July.

Dissolved Oxygen. Plate 32. These findings were not fully satisfactory, the course of the curves at Troy not being in accord with the other findings and as yet not understood. The paper mill effect is noticeable at Middletown, while the results at Sidney were increased by the oxygen given off by growing algae and other vegetation.

Bacteria. Plate 33. The bacterial findings do not stand out so prominently in their indications here as in most of the previous studies, but nevertheless they afford much information. The curve of averages shows an upward inflection at each city or town, and but three exceptions are noted in the monthly curves. At Hamilton in May the above town sample was so greatly increased in number of bacteria from the water of Seven Mile Creek, which had just entered the main stream, that there was a falling off in numbers by the time the curve reached the below town station. At Troy in April the rain during the night previous to the collection of the samples had washed in an abundant supply of organic matter above town, as shown by the highest findings there obtained for the season in free ammonia, nitrites and bacteria. In August at the same station other organic findings were high as well as the bacteria.

The generally high results for April, especially in the northern section, show rain influences with the climax at Piqua. From the averages it would appear that the southern portion of the river was the richer in bacterial life, but it must be remembered in this connection that while the northern samples received a general rain in April, they were but little disturbed at other times, while several of the southern samples received more or less serious additions of surface water and the bacterial fluctuations appear which follow such additions. While sufficient data is lacking for a positive statement, it would seem from certain indications that under similar conditions of weather, the water of the lower portion of the Great Miami River would not be higher in bacteria than the upper portion if as high.

It is to be noticed that the curves do not fall between Sidney and Piqua, and further reference to other plates and to the table shows that the same holds true in general for other determinations. This would indicate the entrance of some pollution between the stations below Sidney and above Piqua.

As shown earlier in the discussion the introduction of the tributary waters from Mad and Stillwater rivers at Dayton, caused some of the findings to indicate in a lessened manner the pollution from Dayton. In contradistinction to these, we would call attention to the unmistakable indications obtained by the Dayton bacterial studies.

The bacteriological findings indicate that after the pollution from Sidney the water fails to again attain a bacterial character as low as it had above Sidney. Only three of the eight samples at the station last named contained over 1000 per c. c., while none of the 96 samples from the other stations contained as low as 1000 bacteria per c. c., the nearest approach being 1100 above Hamilton in September. Taking the average number of bacteria found in eight samples above Sidney we have 1900 bacteria per c. c., and only four out of 96 samples from subsequent stations contain as few as that high number, showing that the water of the Great

Miami is much lower in microbic life above Sidney than at subsequent places in its course.

It would have been desirable to have included, as a part of the regular work, the search for intestinal organisms, but stress of work prevented this procedure except in August, September and a portion of October.

The following table gives the rank of each station by minimum, and then by average findings; the minimum, maximum, and average number of bacteria found. In the last two columns are given the number of months in which the samples were examined for intestinal bacteria and the number of months when colon bacilli were found in that search.

Station.	Minimum rank.	Average rank.	Minimum.	Maximum.	Average.	Samples tested for colon bacilli.	Samples found to contain colon bacilli.
Sidney, above	1	1	450	6,600	1,906	3	0
Hamilton, above	2	9	1,100	84,500	25,350	2	2
Piqua, above	3	*6	1,400	*57,000	*11,075	3	1
Sidney, below	4	2	1,600	10,800	4,750	3	3
Cleves, below	5	5	2,300	17,200	7,038	2	1
Middletown, above	6	7	2,400	54,900	18,888	2	1
Dayton, above	7	3	2,700	17,600	5,600	3	1
Troy, above	8	4	2,800	10,600	5,625	3	2
Middletown, below	9	11	2,800	124,100	42,987	2	2
Hamilton, below	10	10	3,200	78,600	33,400	2	2
Troy, below	11	12	4,000	228,000	51,562	3	3
Dayton, below	12	13	8,100	150,000	65,487	3	3
Piqua, below	13	8	8,900	61,700	22,638	3	3

SUMMARY FOR GREAT MIAMI RIVER.

The summaries for the tributaries Mad and Stillwater rivers have already been given and the following refers only to the Great Miami proper.

Taking the average of the findings of the 104 samples we have the following as the average composition of the Great Miami River:

Color	.26	Chlorine	3.
Turbidity	.60	Alkalinity	211.6
Oxygen required	7.40	Incrusting constituents	22.1
N. as albuminoid ammonia	.339	Total solids	475.
N. as free ammonia	.070	Loss by ignition	135.
N. as nitrites	.016	Dissolved oxygen	8.38
N. as nitrates	.72	Bacteria per c. c.	22793

---

* Omitting the April finding above Piqua, which was an unusual one, the maximum number at that station falls to 8,000, the average to 4,514, and the station receives second rank by averages instead of sixth.

The above is a high turbidity for an average and is somewhat unduly increased by a few excessive findings, but it is true that the water of the Great Miami carries at time of heavy rain a large amount of suspended matter and that it retains for a considerable period a portion of finely divided clay so that clear waters are rarely found in its course. Seven Mile Creek with its clay territory and rather steep flow is one of the greatest producers of roilly water in the state.

The Great Miami River water is hard. The scale-forming element is not so large but its carbonates and bi-carbonates exceed those of any of the streams previously studied. The Olentangy and the Scioto are but little lower in alkalinity but they are much higher in incrusting constituents, than the Great Miami. As hard as is the main stream it is a trifle softer than its two largest tributaries in Ohio. Like some other streams in the state this one contains a large amount of vegetative organic matter. When there is added to this normally high organic content, the various amounts of sanitary and factory sewage which enter at the several larger centers of population there results an undesirable condition of pollution for the water has difficulty in purifying itself by natural processes. It is not to be wondered at that the number of bacteria is so high — an average of nearly 23,000 per c. c. (This figure is slightly increased if the findings on Mad and Stillwater rivers be included). With the water now struggling to regain its normal condition, what will it be a few years hence with the increased pollutions that will come from the growing cities situated on the banks of the Great Miami and its tributaries? It will be only a short time until this stream will need to be protected from the introduction of untreated sewages. At present it does not anywhere show the foul conditions which unfortunately exist on some other streams, but it does receive one pollution after another, with such frequency as to cause the quality of the water at all times to be under suspicion. The water above Sidney cannot be called suitable for a public supply, and while it may have improved in one or two respects at any given place further down the stream, yet on the whole it is even less potable, and therefore it can be said there is no place in its course that the water of the Great Miami River should in its present condition be considered as fit for a public water supply.

REPORT UPON A SANITARY SURVEY OF THE WATERSHEDS OF THE GREAT MIAMI AND LITTLE MIAMI RIVERS.

By BENJ. H. FLYNN,

ENGINEER TO THE OHIO STATE BOARD OF HEALTH.

SYNOPSIS.

I. INTRODUCTION.
II. GENERAL DESCRIPTION OF WATERSHEDS.
III. POPULATION OF WATERSHEDS.
IV. POLLUTION OF WATERSHEDS.
    A. SOURCES OF POLLUTION.
    B. AMOUNT OF POLLUTION.
V. ICE SUPPLIES.
VI. PUBLIC WATER SUPPLIES.
VII. DAMS AND WATER POWER.
AA. STREAM GAGING.

I. INTRODUCTION.

The watershed work for the season of 1900 covered the entire drainage of the Little Miami River and such part of the Great Miami River basin as lies above the junction of the Whitewater River and the above stream. This includes for the Great Miami watershed practically all of the drainage area lying within the state of Ohio and also two small sections just across the Indiana line. The small strip of land below the confluence of the Whitewater and the Great Miami and all the watershed of the former stream, practically all of which is in Indiana, were not touched in this work.

From the nature of the study which is being made by the Board it would be useless to investigate any territory outside of the state or the small stretch of land below the entrance of a large, what may be called, foreign stream into the river under investigation.

The intention has been to keep the scope of the work for the past year, in agreement with that of the previous years, and it is believed that it has been accomplished, though with a little less personal investigation. The methods in use have been more on a parallel with those in use during the latter part of the season of 1899. Before the field work was started in the spring, blanks requesting information as to population, drainage, and neighboring industries were sent to all health officers and township clerks in the area under investigation. These were filled out in a much better manner than usual and a large amount of general information was thus gathered at very slight expense. With the knowledge thus secured the field work could be laid out with a great saving of time and expense in useless trips to small villages containing nothing but a few houses and stores.

As in the previous years all the larger towns were visited and personal investigations made of their water supply and sewerage. These investigations included also all the isolated public and private institutions of any size.

Information was also gathered concerning the general character of the industrial wastes, with special reference to those which affect the purity of the streams into which they are dumped or to which they drain.

Along with the sanitary survey of the watershed as complete information as possible was secured concerning the dams and water-powers. It is hoped that the data on these subjects will be of use in estimating the runoff of the various streams and in accounting for the variation of their flow.

The investigation of the ice supplies was limited as in the previous year, to a mere outline of the sources from which the bulk of the supply is obtained.

II. GENERAL DESCRIPTION OF WATERSHEDS.

The Miami watersheds occupy a large portion of the southwestern part of Ohio and a considerable area in the south-eastern part of Indiana. The Little Miami watershed lies to the east and south of the Great Miami watershed and to the west of the Scioto River basin. The waters from its southern border are carried by short turbulent creeks direct to the Ohio River.

The Great Miami watershed is much larger than that of the Little Miami and extends on the north to the area drained by the extreme northern tributaries of the Scioto and Wabash rivers and the southern tributaries of the Maumee. The western part of this basin, in Indiana, borders on territory tributary to White River, a branch of the Wabash.

The western tributary of the Great Miami River, the Whitewater River, enters it only five miles from the confluence of the former with the Ohio, and for the purposes of this investigation it was separated from the Great Miami River, as nearly all of its drainage area lies within Indiana.

The Great and Little Miami rivers occupy rather narrow valleys, with the general axis of each lying east of north.

It will be noted that the main drainage lines of the Great and Little Miami watersheds occupy respectively the eastern and western portions of the drainage areas so that the Great and Little Miami rivers are brought quite close together, with the principal tributaries joining them from the opposite sides. The one exception to this is Mad River which enters the Great Miami at Dayton from the east. The lower portion of these two watersheds are separated by a small area tributary to Mill Creek and to the Ohio River direct.

The Miami watersheds include all of Miami, Montgomery, and Warren counties, the major portion of Butler, Champaign, Clark, Clermont, Clinton, Darke, Green, Logan, Preble, and Shelby counties, and small portions of Auglaize, Brown, Fayette, Hamilton, Hardin, Highland, Madison, and Mercer, also of Franklin, Randolph, Union, and Wayne counties, Indiana. The above description only takes in the portion of the Great Miami watershed that is above the Whitewater River.

AREA.

The total area of the Great Miami watershed is 5247 square miles, of which 1355 square miles are in Indiana and the remaining 3892 in Ohio.

The total area of the Little Miami watershed is 1709 square miles, all of which is in Ohio.

The total for the two watersheds is 6956, of which 5601 square miles are in Ohio. The area above the confluence of the Whitewater River and the Great Miami is 3809 square miles, of which 81 are in Indiana. This last named area of 3809 square miles gives the extent of the territory which it was intended to cover in this survey, making the total area covered, with the Little Miami, 5518 square miles, something over 1000 square miles less than was gone over the previous year.

These areas were determined by careful planimeter measurements from the State Board of Health watershed map of Ohio and from the General Land Office map of Indiana. The Ohio areas are probably more accurate than those in Indiana, but they all agree fairly well with the results of other investigations.

For convenience in studying it, the Great Miami watershed has been divided into four subsidiary watersheds, namely: Stillwater, Mad, Upper Great Miami, and Lower Great Miami. The first two names are self-explanatory, the third name is applied to all the territory above Dayton and between Mad and Stillwater rivers, and the fourth includes all the territory below Dayton and the Mad and Stillwater basins. The Little Miami watershed was not subdivided.

The areas of these subsidiary watersheds together with many of the still smaller streams are given in the following table:

TABLE I — AREAS OF WATERSHEDS.

Watershed.	Area in Square Miles.
Stillwater River	653
Greenville Creek	200
Upper Great Miami	1,158
Loramie Creek	244
Mad River	645
Buck Creek	160
Lower Great Miami (above Whitewater)	1,353
Indian Creek	129
Seven-Mile Creek	282
Twin Creek	321
Total for Great Miami River (above Whitewater)	3 809
Great Miami River below and including Whitewater	1,438
Total for Great Miami River	5,247
Little Miami River	1,709
Cæser's Creek	237
Todd's Fork	241
East Branch Little Miami River	475
Total for Little Miami River and Great Miami River (above Whitewater)	5,518
Grand total for Miami Rivers	6,956

GENERAL TOPOGRAPHY.

As a general statement the Miami watersheds, with reference to the surface formations, occupy a place in between the Maumee and Sandusky basins on one hand and the Muskingum on the other. In the district under discussion there are found greater extremes of elevation than in any other portion of the state, but the slopes are more uniform, the surface more rolling, than is found in the Muskingum watershed and there is none of the level prairie formation that is found in the north-western part of Ohio.

A dictionary of altitudes published by the U. S. Geological Survey gives the mean low water level in the Ohio River at the confluence of the Great Miami as 425 feet above sea level and the elevation of a point east of Bellefontaine as 1540 feet, these are the extreme elevations of the State.

The north-western part of the Great Miami basin and the north-eastern part of the Little Miami consist of comparatively level elevated areas, marked, however, with rolling glacial moraines. Between these two districts and connecting the extremes of elevation mentioned above there is a wide strip of quite hilly and heavilly rolling land with a rather steep slope to the south-west. A narrow strip of high land running lengthwise of this area forms the dividing line between the Great and Little Miami basins.

As the entire area of both watersheds has been glaciated the surface presents the smoothed-over appearance which accompanies this phenomenon and no abrupt changes are to be found except where the streams have cut out their valleys in the soft drift.

The surface is covered with wide areas of a heavy limestone soil crossed with narrow stretches of a loamy and gravelly soil. Some of the stream valleys contain extensive alluvial deposits, forming very fertile areas for cultivation. Much of the clay sub-soil of the southern part of the Little Miami watershed is covered with loam, forming on the level uplands excellent farming districts.

As the whole district is essentially an agricultural one the timber was rapidly cleared off and but small isolated wood lots now remain over the tillable portion. Along the steep hillsides and the streams there are still found stretches of forest, much of which is scrub or young growth, all the merchantable timber having been cut out.

The lower and rougher portions of the Little Miami watershed contain the most heavily wooded areas to be found in either basin. Here on the steep hills bordering the streams there are still to be found many good tracts of timber, the inaccessability of which has so far prevented their destruction.

Corn, wheat and tobacco are the staple crops, the last being important in both districts. On account of the proximity of the large urban population in and around Cincinnati, quite extensive dairy interests have been built up.

Good roads cover nearly all of both watersheds, indicating better than anything else that they are rich districts inhabited by a prosperous and enlightened people.

GEOLOGY.

As stated both areas have come under the influence of the glacial action which has covered the original strata with a layer of drift from 5 to more than 100 feet thick.

Practically all the bed rock belongs to the Silurian age, with the Hudson River group, the Utica shale, and the Trenton limestone covering the entire southern portion of both watersheds, while to the north and east there is a wide band of the Niagara, Clinton, and Medina group, and to the extreme northeast is found the lower Helderberg and Waterlime group.

On the high elevation east of Bellefontaine there appear small areas of both groups of the Devonian age; the Hamilton and Upper Helderberg and the shales.

Near Dayton and in the valleys of the Stillwater at Covington and of the Mad River below Springfield there are quite extensive limestone quarries. At the latter place and at Cedarville on Massicks Creek a considerable quantity of limestone is taken out to be roasted for lime.

DRAINAGE.

The main drainage line, the Great Miami River, of the Great Miami watershed starts at the extreme north-eastern part of the district and runs in a south-westerly direction, joining the Ohio River at the Ohio and Indiana state line. Until Dayton is reached it occupies the central portion of the watershed but from that point on it lies very close to the eastern edge of its drainage area. Below Dayton its tributaries, not considering the Whitewater River, consist of Indian, Seven Mile, and Twin creeks, each of which drains a long and narrow strip of territory. At Dayton the main stream receives two large tributaries; the Mad River from the east and Stillwater River from the west.

In the Little Miami watershed the main drainage line, the Little Miami River, rises in the extreme northern part of the district and flows south-west keeping close to the western boundary for its whole length and finally joining the Ohio a few miles above Cincinnati. Its principal tributaries, all coming in from the east, are the east branch of the Little Miami, Todd's Fork, Caesar's Creek, and Massick's Creek, the first named being the most important.

The length, total fall, and fall per mile of the main streams and tributaries of both watersheds are shown in the following table:

TABLE II — APPROXIMATE GRADIENT OF PRINCIPAL STREAMS.

Stream	From	To	Distance in Miles.	Total Fall in Feet.	Average Fall per Mile.
Great Miami River	Ohio River	Hamilton	33	145	4.4
“ “ “	Hamilton	Dayton	44	160	3.6
“ “ “	Dayton	Piqua	33	110	3.3
“ “ “	Piqua	Degraff	27	120	4.4
“ “ “	Degraff	Headwaters	26	90	3.5
“ “ “	Ohio River	“	163	625	3.8
Stillwater River	Dayton	Covington	30	150	5.0
“ “	Covington	Headwaters Greenville Creek	36	240	6.7
“ “	“	Headwaters Stillwater River	32	165	5.0
“ “	Dayton	Headwaters Greenville Creek	66	390	5.9
“ “	“	Headwaters Stillwater River	62	315	5.1
Mad River	“	Springfield	23	170	7.4
“ “	Springfield	Headwaters	35	300	8.6
“ “	Dayton	“	58	470	8.1
Twin Creek	Great Miami River	“	48	450	9.4
Seven-Mile Creek	“ “ “	“	34	510	15.0
Little Miami River	Ohio River	Milford	13	66	5.1
“ “ “	Milford	Waynesville	35	180	5.1
“ “ “	Waynesville	Headwaters	46	450	9.8
“ “ “	Ohio River	“	94	696	7.4
E. Branch L. Miami R.	Little Miami River	Batavia	12	105	8.8
“ “ “ “ “	Batavia	Williamsburg	19	200	10.5
“ “ “ “ “	Williamsburg	Headwaters	42	300	7.1
“ “ “ “ “	Little Miami River	“	73	605	8.2

It is evident at once from this table that all the streams of the watershed have very rapid rates of flow. Even the lowest average gradient, 3.3 feet per mile as found between Dayton and Piqua, is sufficient in a large stream to give a very good current. The Great Miami River has throughout its entire course a very uniform gradient, more so than is usually found in such a long stream. Mad River also has a quite uniform but a much steeper gradient. As would be expected the streams, Seven Mile and Twin creeks, coming down from the high land near the Indiana line have a very high gradient, the highest to be found in both watersheds. The upper part of the Little Miami River and the east branch of the same stream also have high rates of flow induced by steep gradients. At one time advantage was taken of these excellent streams by numerous water powers but now many of these have been abandoned. This question will be taken up later in connection with the descriptions of the water power still in use.

Owing to the extensive use of the land for agricultural purposes there are no extensive tracts of swamp land left. Many large areas have been ditched and tiled turning what was formerly waste land into exceptionally fertile fields.

The valley of the Mad River between Dayton and Springfield, except immediately below the latter city, is very low and swampy, much of it being so low that it can with but great difficulty be drained for use. Along this same stream, in Champaign County, there are large areas of low, wet, peaty land which has as yet not been successfully drained.

III. POPULATION.

For the first time since the beginning of this work has it been possible to make a satisfactory study of the population on the watersheds under investigation. For this year the reports of the 1900 Census are available, and as accurate data as it is possible to secure in this country could be had for the work.

The figures for urban population are accurate except where a city is on the dividing line of the watershed, when it was necessary to estimate the population within the watershed. This occurred only in three cases; Cincinnati, Evanston, and Hyde Park, portions of each of which are in the Little Miami drainage area.

The same figure, 1000, has been assumed for the dividing line between urban and rural when classifying the villages, though in these districts a larger one could be better used than in any of the former cases on account of the large number of villages with populations above this figure and still unprovided with public improvements. It is true also that any material raising of the standard would throw into the rural population many villages which have public water supplies and more or less sewerage.

In determining the rural population, the population of every village it was possible to obtain was subtracted from the total township population and the remainder assigned to the proper watershed according to the area each contained, then the village populations were assigned to their proper districts.

Using these methods the total population of the entire Great Miami watershed in Ohio and Indiana was 520,698 of which 258,859 was classed as urban and 261,839 as rural. Of the total population 89,814 was in Indiana, divided as follows: urban 32,062 and rural 57,752.

For the Great Miami watershed above Whitewater, as used in this report, the total population was 430,884 of which 226,797 was urban and 204,087 was rural. Of this rural population 3647 was in Indiana; there was no urban population in Indiana within the watershed proper.

The total population of the Little Miami watershed was 120,959 of which 39,645 was urban and 81,314 rural.

These same figures for the subsidiary watersheds, for both watersheds and for the state, also the population of each class per square mile are given in the following table.

TABLE III — POPULATION ON WATERSHEDS.

Watershed.	Total Population.			Population per Square Mile.		
	Urban.	Rural.	Total.	Urban.	Rural.	Total.
Stillwater	11,249	39,921	51,170	17.2	61.1	78.3
Upper Great Miami	34,708	56,027	90,735	30.0	48.4	78.4
Mad River	47,519	29,785	77,304	73.7	46.2	119.9
Lower Great Miami	133,321	78,354	211,675	98.5	57.9	156.4
Total for Great Miami	226,797	204,087	430,884	59.5	53.6	113.1
Little Miami	39,645	81,314	120,959	23.2	47.6	70.8
Total for Miamis	266,442	285,401	551,843	48.3	51.7	100.0
The State	2,202,857	1,954,688	4,157,545	54.0	48.0	102.0

This table shows that for the Great Miami watershed both the urban and the rural population are in excess of the average for the state while in the Little Miami watershed the urban population is less than one-half of the average and the rural is the same as the average rural for the state. For both watersheds the average urban population is 6 per square mile less and the rural 4 per square mile in excess of the averages for the state, making the total average only two less than the total for the state, 102 per square mile.

Contrary to expectations both the Stillwater and Upper Great Miami watersheds have an average population per square mile but little in excess of that for the Little Miami watershed with its large area of rough hilly country. Dayton and Springfield are responsible for the large urban population in the Lower Great Miami and the Mad River districts, respectively.

It will be interesting to note that in the small area, 216 square miles, between the Miami Rivers, and tributary to Mill Creek and to the Ohio River district, there is a total population of 375,571 of which 350,894 is urban and 24,677 rural. This gives an average population per square mile as follows: urban 1625, rural 114, and a total of 1739.

The sewage of a good per cent. of this enormous population together with millions of gallons of objectionable industrial wastes finds its way to Mill Creek, turning the latter into an exceedingly foul open sewer.

IV. POLLUTION OF WATERSHED.

A. SOURCES OF POLLUTION.

The factors to which the pollution of the watersheds is due are, as formerly stated, farm drainage, sewage of towns and institutions, the drainage from dumps, and industrial wastes. As this subject was fully discussed in the report on the pollution of the Muskingum watershed in the 1899 annual report, it is not considered necessary to go into details here.

It will suffice to say that farm drainage is meant to include all the wastes from the rural population and from that portion of the urban population that is not within reach of sewers. In this class there should be placed the pollution caused by the excrementatious matter of domestic animals which is found spread over fields as manure, heaped up in barn-yards and pig pens, and scattered over streets and roads. Country slaughtering, surface privies, kitchen slops, etc., also add much to the pollution of the small streams draining rural communities.

The most serious pollution of the streams of course is to be found in the sending of sewage of towns and public institutions direct to them for disposal. The storm water sewers, of a thickly settled community, carry in concentrated form, much of the objectionable refuse which is responsible for the so-called rural pollution.

Under the head of pollution caused by dumps is included the very offensive drainage from night soil and garbage dumps and tipping grounds and the less objectionable leechings from general refuse heaps. A no more foul and disgusting thing can be imagined than the dumping of night soil and dead animals into the streams or so near them that every rain or high water washes the stuff into the channel.

The industrial wastes of the Miami watersheds differ from those of the Muskingum district in the absence of coal mine drainage and the addition of a large amount of waste from paper mills. This latter is especially true of the Great Miami river which has on its borders a number of large paper mills which send their refuse direct to the streams. Briefly this waste consists of the filth, both organic and inorganic, washed and bleached from the stock from which paper is made, and of the chemicals used in this, and also the final process of mixing, coloring, etc. These consist of bleaching preparations, chlorine, and lime, the various acids separating the fiber, and cleaning machinery, and the dyes and filling material used in the final finishing.

With the exception of this one industry which is peculiar to this section the remainder of the manufacturing plants are such as are found throughout the state. These consist of breweries, cider mills, canning factories, distilleries, strawboard works, wood-working shops, etc., the waste from which is in general vegetable; then creameries, cheese factories, slaughter houses, soap and rendering works, tanneries, woolen mills, etc., which send out animal refuse, and finally those turning out mineral waste, as gas works, metal-working shops, etc. It may be stated that the easily decaying vegetable, all the animal, and a few of the mineral wastes cause a nuisance, while practically all the industrial wastes if present in quantity destroy the potability of a water.

As a general rule it is probably true that as soon as a water polluted by industrial wastes recovers its physical purity, so to speak, it has recovered its potability, while a sewage polluted water cannot be considered within reasonable limits as ever again becoming potable. In some cases an industrial waste may supply the food necessary for the maintenance of harmful bacteria in a water and in this way destroy the usefulness of stream as a source of water supply.

B. AMOUNT OF POLLUTION.

Under this head there will be given a brief description of the larger towns, with their industries, sewerage, etc., and any special source of pollution. For the smaller places, the combined population, industries, etc., on each small tributary, will be given so as to make it possible to form some idea of the character of the water to be expected in these streams. These small tributaries will be taken up in order, beginning at the mouths of the Great and Little Miami rivers respectively, and bringing in each stream in its turn.

Details of the sewerage systems and water supplies of both towns and institutions will be given in special sections following the one in question.

1. LOCATION AND AMOUNT OF ALL THE ABOVE MENTIONED SOURCES OF POLLUTION.

a. GREAT MIAMI RIVER.

Taylor's Creek. This stream drains the very hilly portion of Hamilton county just west of Cincinnati, on which are the small villages of Sheartown and Dent. The combined population of these is some 300 and neither has any industries.

Miamitown. Population 400. Here there is located a small saw mill and cider press.

New Baltimore. Population 125. In the Great Miami River opposite this place is a small dam supplying water-power to a combined saw and flour mill.

Ross. Population 300. This village supports a flour mill and two saw mills.

Indian Creek On this long and narrow watershed there are the villages of Millville, Woods, Reiley, Mixerville, College Corner, Cottage Grove, Goodwin's Corner, and Beechmire, the latter ones being in Indiana. The combined population of these villages does not exceed 1400 with 500 for the largest, College Corner. There is still some lumber left in this section and nearly every village has one or more saw mills.

Symmes Corner. Population 135. This village is on a small creek which enters the river a few miles below Hamilton.

Hamilton. Population 23,914. This city, the county seat of Butler County, is drained by the Great Miami River, passing through its center, and the Miami and Erie canal through its eastern portion. It has a good water supply and quite an extensive system of both sanitary and storm sewers. It is estimated that the sewage of 4700 people is sent to the river direct. The large per cent. of the population not accessible to the sewers, use walled up vaults, very few of which are water-tight. These must be cleaned out and the night soil is hauled to the country, a little being dumped into the river however. Kitchen garbage and refuse in general is tipped on low land near the river where it is finally washed into the latter by high water. There are supported here a large and varied assortment of industries, among which are two large paper mills, two safe and lock factories, several large foundries and machine shops, agricultural implement works, shoe factory, a number of important wood working shops, malting house, brewery, flour mills, carriage factory, gas works, etc. Many of these concerns are furnished power from the Hamilton hydraulic which obtains its water from the Great Miami River some five miles above the city. The public water supply is of good quality and is in general use. Those not using the same must depend on wells, most of which are driven from 20 to 60 feet into a bed of sand and gravel.

Butler County Infirmary. Population 152. The sewage from this whole institution is emptied into an open pit which drains through a small run, direct to the Great Miami River.

Seven Mile Creek. This, one of the large tributaries of the Great Miami, joins the latter only a few miles above Hamilton. A short distance above its mouth the stream branches, with Four Mile Creek turning off to the west.

Four Mile Creek. On this watershed in addition to Oxford there are the villages of Darrtown, Morning Sun, Fair Haven, West Florence, and Campbellstown. The combined population is 550 and the industries consist of a few scattered saw mills.

Oxford. Population 2009. This village has a public water supply but no sewers outside of those found in the four institutions located in and near it. Several house drains lead out on the fields from which some of the sewage is washed to the creek. The village is an educational center with its industries limited to a saw mill, flour mill, and planing mill. Those not using the village water obtain their supply from wells dug 15 to 20 feet into hardpan, gravel and rock. In the Miami University, Oxford College, The Western and Oxford Retreat there are something over 500 people. Each of these institutions is furnished with a water supply under pressure and with sewered closets, the waste from which reaches the creek by more or less direct routes.

Seven Mile Creek. On the main branch of the stream there are, in addition to Eaton, the villages of Seven Mile, Collinsville, Somerville, Camden, and Upshur. In all these have a population of 1770, of which 905 belong to Camden, the largest of the group. The industries of these villages consist of the usual saw and planing mills for each, with the addition of a creamery and flour mill in Camden.

Eaton. Population 3155. This village, the county seat of Preble county, has a good public water supply but no sewers beyond a few short storm drains. Vaults are constructed in any and every way and but few are ever cleaned out, many being covered over when full. Garbage and night soil are hauled to the country and there disposed of.

The industries consist of a canning factory, flour mill, two saw mills, glove factory, furniture factory, tile mill, ice factory, etc.

The private water supply is of less importance each year as the village water is introduced. The wells in use are dug from 12 to 40 feet deep into gravel and rock, the latter appearing in the western part of the village.

Preble County Children's Home. Population 54. As yet this institution sends no sewage to the creek but extensive improvements are being made and very soon both inmates and officers will have the use of sewered closets.

Preble County Infirmary. Population 55. The infirmary is provided with sewered closets which are used by some twenty people, the remainder using outdoor vaults. The sewage is sent to a small cesspool or pit which holds back much solid matter but allows the liquid portion to pass direct to the creek.

Gregory Creek. Tributary to this small creek are the villages of Lesourdville, Monroe, Huntsville, Hughes, Bethany, Tylersville, and Mauds. The combined population is 690 and the industries consist of a flour mill, and a few small tile and saw mills.

Dick's Creek. The drainage of Amanda and Excello goes to this creek and to the Miami and Erie canal. These villages have populations of 210 and 120 respectively, and each supports a large paper mill.

Elk Creek. In the watershed of this creek are the villages of Trenton, Miltonville, Jacksonboro, Greenbush and West Elkton, whose combined population is nearly 900. The industries of these consist of two small saw mills and a buggy factory. At Trenton are located the car barns for one of the interurban electric roads.

Great Miami River.

Middletown. Population 9,215. This city occupies the east side of the Great Miami River, with a small suburb Heno, on the west bank. Middletown has an excellent water supply and a rather extensive system of combined sewers, which carries the sewage of some 2000 people direct to the Great Miami River. Those not accessible to the sewers use vaults which must be ten feet deep but are not required to be water-tight unless they are in the upper end of town near the water works well, in the neighborhood of which an attempt is being made to protect the sub-surface water. Night soil and garbage is dumped in and near the river just below the city. Dead animals are buried in the gravel near this point.

The waste from a large number of manufacturing establishments finds its way to the river also; a small amount however goes to the canal. Among the industries are five large paper mills, a large tobacco factory, tobacco warehouses, rolling mill, bicycle factory, machine shops, carriage works, brewery, malt house, slaughter houses, gas works, flour mill, saw mills, etc. The refuse from the paper mills is so profuse in quantity that the river at times is discolored for a considerable distance.

The private water supply is obtained from wells both dug and driven, from 12 to 15 feet into the gravel which underlies the whole city. In the central and lower portion of Middletown the well water cannot be of good quality owing to the pollution caused by the deep vaults.

Twin Creek. This stream drains quite an extensive watershed on which are located a few very good villages together with the following smaller ones: Johnsville, Farmersville, Winchester, Lanier, New Lexington, Eldorado, Pyrmont, Euphemia, West Baltimore, Verona, Gordon, Sonora, Ethica, West Manchester, Castine. These have a combined population of 3,200, and number among their industries some dozen saw mills, two tile works, two creameries, flour mills, planing mills, cider presses, elevators, etc.

Germantown. Population 1,702. This is quite an old but substantial village, which has slipped away from the path of industry much to its detriment. Its industries at present consist of a flour mill, creamery, cigar factory, tobacco warehouses and a distillery some distance outside of the corporation. There are a few storm sewers in the village but none for house drainage, and every one must use the out-door vault. The construction of these is not regulated, and many of them are never cleaned.

The water supply is from private wells both drilled and dug from 18 to 25 feet into a bed of gravel underlying the village.

West Alexandria. Population 740. This village has a very good public water supply but no sewers beyond a few storm water drains. Vaults are constructed to suit the owner and quite a number are never cleaned, new ones being dug to replace the old ones. A large number of people still obtain their drinking water from wells dug from 18 to 35 feet into a bed of gravel found below the clay.

Lewisburg. Population 560. This is a growing village now supporting a grist mill, two saw mills, grain elevators and a stone quarry, some of the product of which is burned for lime.

Clear Creek. This stream drains the villages of Springborough, Red Lion, and Dodds, the total population of which is 650, and whose industries consist of a few saw mills and a creamery.

Great Miami River.

Franklin. Population 2,724. This village has a public water supply and a few short combined sewers which carry direct to the Great Miami River the sewage of some 400 people. The houses not accessible to the sewers are provided with vaults constructed in any manner but which must be cleaned out and the contents hauled to the country. Some garbage is hauled out to the farms but much of it is dumped into the river.

The industries consist of four paper mills, flour mill, saw mill, and two slaughter houses in Clear Creek. One of the paper mills and the saw mill are furnished with water power from the river.

Private wells obtain their water from the sand and gravel only a few feet below the surface.

Carlisle. Population 260. The drainage from this village reaches the river through a small creek.

Miamisburg. Population. 3,941. This village has no public water supply and no sewers beyond a few storm water drains. Surface drainage is to the canal and the river. Formerly the construction of vaults was not regulated and they were never required to be cleaned but now they must be water-tight and the contents must be hauled regularly to the country.

In the way of industries there are three paper mills, several tobacco warehouses, a foundry, two large carriage factories, a wheel factory, twine factory, flour mill, planing mill, etc. Two of the paper mills, the planing mill, and the flour mill are run by water power. The water supply is from private wells, the majority of which are dug from 30 to 35 feet into a gravel bed, while a few are driven through this gravel and into a soft stone below a layer of hardpan.

Bear Creek. On this small watershed are to be found the villages of Gettersburg, Liberty, and New Lebanon, the combined population of which is 440 and whose sole industries consist of one or two saw mills.

Great Miami River.

West Carrollton. Population 987. This village is situated a short distance back from the river on the Miami and Erie canal, to which some of its surface drainage goes. It has a public water supply but no sewers except a short one for storm drainage. The construction of vaults is not regulated and the ground water is no doubt seriously polluted by the careless methods in use.

The sole industry of the village consists of a large paper and pulp mill which employs some 700 people, many of whom are from the neighboring towns. The waste from this plant together with the sewage from a large portion of the employes goes direct to the canal.

The private water supply is obtained from wells driven from 20 to 26 feet into the gravel.

Alexanderville. Population 200. The inhabitants of this village are employed at the West Carrollton paper mill. Just above the village the canal furnishes water power to a flour mill.

Montgomery County Infirmary. Population 414. All the inmates and officers of this institution have the use of sewered closets, the waste from which is first purified in an intermittent filtration plant before being turned into Oppossum Creek, which carries it to the river.

National Soldiers' Home. Population 4,850. This institution, a city in itself, is furnished with its own water supply and an extensive sewer system which carries the liquid wastes of every kind direct to the Great Miami River. From this one institution more sewage is sent to the river than from any city in either watershed, with the one exception of Dayton.

Dayton State Hospital. Population 960. This asylum, located just south of Dayton, has a complete system of sewers and a water supply under pressure. The sewage is emptied direct to the Miami and Erie canal at a point west of the institution.

Dayton. Population 85,333. This city is the largest in both watersheds, and the fifth largest city in the state. It is situated at the junction of Mad and Stillwater rivers with the Great Miami River and is the site of one of the earliest settlements in the Miami valley.

The city has an excellent public water supply and extensive systems of both sanitary and storm sewers. To the former it is estimated that some 30 per cent. of the people have access, and that some 15,000 have the use of the same. All the sanitary sewage is conducted to one outfall sewer which carries it direct to the Great Miami River at a point opposite the lower portion of the city. The storm water drainage together with a large portion of the industrial wastes is emptied into the various water courses, including the canal and hydraulic, at the most convenient point. The large per cent. of the population not accessible to the sewers still use the ordinary out-door vaults, but their construction is regulated to some exent and they are required to be cleaned as necessary. Garbage, dead animals, and some night soil are cremated in the municipal crematory in the southern part of the city. Some night soil is carted to the country and disposed of on the farms. This crematory contains four Dixon furnaces, fired with both coke and natural gas; the former however is only used to burn the offensive gases given off during the cremation. The garbage is collected and brought to the furnace by five two-horse and three one-horse self-dumping wagons. For the year ending February 1, 1900, there were cremated 66,765 bushels of garbage, 6,754 barrels of night soil, 892 dogs, and a few horses and miscellaneous animals. The plant is operated by three men, at a cost per year of $1,719.75 for labor, $4,278.66 for fuel, and $2,076.25 for repairs, principally grate bars, or a total of $8,074.66. For the same year $1,729.81 was collected for the destruction of refuse for private parties, making the net cost of operation $6,244.85. The ash from the furnaces is dumped on low ground near the plant.

There is a large and varied assortment of industries in and near the city, which send a considerable quantity of objectionable waste to the streams. Among these are nine breweries, several large slaughter and packing houses, a lard oil mill, linseed oil mills, four soap works, gas works, a number of paper mills, a strawboard works, etc., together with a large number of plants for general manufacturing, the waste from which is not so objectionable.

Owing to the excellent quality of the city water supply the use of private wells is being discouraged, although there are of necessity quite a number still in use. These are both dug and driven from 30 to 60 feet into the gravel which underlies the city.

Wolfe Creek. This stream enters the Great Miami River at Dayton, bringing to the latter the drainage from Arlington, Wengerlawn, Amitz, and Salem, in addition to that of Trotwood and Brooksville. The first villages named have a total population of 520, and a list of industries including three saw mills and a flour mill.

Trotwood. Population 214. This village has a public water supply which was introduced for fire protection and is not in general use for domestic purposes. The private water supply is from wells driven from 21 to 26 feet through hard-pan into gravel. This is protected to some extent by compelling all vaults to be made fairly tight and to be cleaned out as often as necessary.

The industries consist of a creamery, canning factory, saw mill, wagon works, incubator factory, etc. All drainage is direct to Wolfe Creek through surface ditches and gutters.

Brookville. Population 869. The industries of this village consist of a flour mill, grain elevators, tobacco warehouses, creamery, machine shop, etc. The drainage of these is direct to south branch of Wolf Creek.

Mad River. This drains the large eastern part of the Great Miami watershed, including nearly all of Clarke and Champaign counties.

Harshmanville. Population 300. This was the site of a large paper mill which was destroyed by fire a number of years ago. There was also developed here an extensive water-power which ran an oil mill, malt house, flour mill, saw mill, etc. The flour mill has now been turned into a shoe factory which uses some of the water power.

Fairfield. Population 312. The drainage of this village, which supports a small saw and grist mill, is carried by a small creek to Mad River.

Dry Run. On the watershed of this small creek there are the villages of Sulphur Grove and Brandt, whose combined population is 300 and whose industries consist of a saw mill and cider press.

Mad River.

Osborn. Population 948. This village has a public water supply which is as yet not in general use; shallow driven wells supplying nearly all the water for domestic purposes. Owing to the lax methods of constructing vaults, and in caring for them, the ground water cannot help but be polluted, and the use of the public supply should be encouraged. The industries consist of a saw and planing mill, three flour mills, two run by water-power, a whip factory, bed spring factory, etc. The village has no sewers; all drainage is direct to the river and mill-race.

Medway. Population 300. An electric railroad power house is located here.

Donnell's Creek. Donnellsville, Northampton, and Dialton are situated on this stream. Their total population is 450 and their industries consist of a few saw mills, a cider press, feed mill, and tile mill.

Mad River.

Enon. Population 295. This is a quiet village about a mile back from the river.

Noblesville. Population 100. Dry Run brings the drainage from this village to the river. Its industries consist of a tomato canning factory, sorghum mill, cider press, and saw mill.

Masonic Home. Population 160. This institution consists of one large building, fitted with all modern improvements, situated on the high ground back from Mad River and overlooking Springfield. Its sewage is carried direct to the river.

Buck Creek. Just before this stream joins Mad River it receives the sewage of Springfield, Knights of Pythias Home, Odd Fellows Home, and of the Clarke County Infirmary. Just above Springfield the main stream turns to the north and quite a large tributary, Beaver Creek, comes in from the east.

Springfield. Population 38, 253. This city has a good public water supply as regards quality, but a very poor sewer system. Including private sewers it is estimated that some 20 per cent. of the people have access to the system and that some 3,000 have the use of the same. Those not accessible to the sewers use vaults, very few of which are tight, but all of which must be cleaned as necessary. Garbage and night soil are dumped and buried along the banks of Mad River just below the city. Dead animals are boiled down in two small plants and the waste thrown into the river or fed to hogs. It is hard to imagine a method of disposing of the refuse of a city that is filthier, more unsanitary, and more objectionable in every way than the one used in this city. To this fated spot on the banks of a once beautiful river there is a continual stream of garbage and night soil wagons and dead animals. The disposition of this stuff is not supervised in any way and it takes but a very short visit to convince one of the fact that it is cared for in any but a sanitary manner.

The industries of Springfield consist of several large argicultural implement works, together with a great number of metal-working concerns; such as foundries, iron mills, engine works, machine shops, etc. These are supplemented by the usual general manufacturing establishments, flour mills, saw and planing mills, ice plants. gas works, a brewery, etc.

On account of the good quality of the city water, private wells are used only when necsssary. They are usually dug from 15 to 40 feet deep into the gravel and sand found below the surface soil.

Knights of Pythias Home. Population 136. This institution obtains its water supply from the Springfield water works, and the sewage of all its residents goes direct to a Springfield sewer, making it rather a part of the city than an isolated institution.

Odd Fellows Home. Population 173. This Home also obtains its water supply from the Springfield water works, but its sewage is sent direct to Buck Creek.

Clarke County Infirmary. Population 162. For general purposes this institution uses the Springfield city water, but the drinking water is obtained from shallow dug wells It is estimated that at least 150 of the officers and inmates use indoor closets sewered to a mill-race leading to Buck Creek. The few remaining use outdoor vaults.

Clarke County Children's Home. Population 85. All the residents of this Home use closets sewered to a small run which empties into Buck Creek. The water supply is obtained from a number of 50 foot wells.

Beaver Creek. On the watershed of this stream there are the small villages of Harmony, Plattsburg, Vienna Cross Roads, Brighton, and Orchard. The total population of these is 775, and their industries consist of three saw mills, a tile mill, and the usual small slaughter houses.

Buck Creek. On this creek above Springfield are located the villages of New Moorfield, Catawba, Powhatan, and Mutual, the population of which is 625. Their industries consist of two or three saw mills, a cider press, creamery, and a water-power flour and feed mill. At one time there were several water-power flour mills on this creek, and two abandoned ones are still standing near Powhatan.

Mad River. This stream above Springfield drains quite a number of small villages and the larger village of St. Paris and the city of Urbana.

Chapman Creek. On this stream a short distance back from the river is the village of Tremont, with a population of about 400, and the following industries: saw mills, a water-power flour mill and feed mill, and a slaughter house.

Storm Creek. Farther back from the river on this creek is Terre Haute, a village containing some 90 people and a saw mill and cider press.

Nettle Creek. On this watershed are the villages of Westville and Millerstown, the combined population of which is 400, and whose industries consist of a saw mill, hoop factory, and fertilizer works.

St. Paris. Population 1,222. The drainage from this village goes to Nettle, Storm and Chapman creeks. Beyond grain elevators and a flour mill it has no industries.

Mad River.

Champaign County Infirmary. Population 77. The sewage from some 50 of the occupants of this institution is carried to a cesspool which overflows to a small run leading to the river. The others use unsewered vaults. The water supply is from the Urbana water works, a spring, and a 50 foot dug well.

Dugan Creek.

Urbana. Population 6,808. This city has a public water supply but as yet no sewers whatever beyond a few short storm water drains. It is probable, however, that the creek receives the sewage from a number of places through private sewers. A number of water closets are sewered to cesspools dug down into the gravel so as to require less frequent cleaning. Vaults are also dug down to gravel and when full are covered over and new ones dug. Very few cesspools or vaults are ever cleaned out.

The private water supply is obtained from this same and deeper stratas of gravel and cannot help but be of uncertain quality.

The industries of the city consist of a woolen mill, dye house, strawboard works, fruit canning and packing houses, creamery, car shops, artificial ice plant, gas works, and some general manufacturing.

Champaign County Children's Home. Population 55. The sewage from the entire population of this Home is sent to cesspools which overflow of Dugan Creek. The water supply is obtained from the Urbana water works.

Mad River. Above Urbana this river drains the villages of King's Creek, Kennard, Cable, Mingo, West Liberty, and Zanesfield. The total population of these is 2,300, of which the largest, West Liberty, has

1,236. The industries include three or four saw mills, three small water-power flour mills, two of which are but little used, a creamery, and a few cider presses.

Stillwater River. This river joins the Great Miami at Dayton, and brings in the drainage from nearly all of Darke county and portions of Montgomery, Preble, and Miami counties, and a small portion of Indiana. Up to Ludlow Creek the river drains the village of Little York, Union, Fidelity, Nashville, and West Milton. These have a total population of 1,850, of which West Milton has 904. The industries consist of four saw mills, a creamery, woolen mill, cider press, and two flour mills, with several more feed and flour mills scattered along the river.

Ludlow Creek. On the drainage area of this creek are the villages of Ludlow Falls, Laura, New Lebanon, Phillipsburg, and Pittsburg. These have a total population of 1,160, and their industries consist of four saw mills, a flour mill and a cider press.

Stillwater River.

Pleasant Hill. Population 557. The industres of this village consist of a canning factory, saw mill, and plaster works.

Painter Creek. This brings in the drainage from Painter Creek, Delisle, and Arcanum, which villages have a total population of 1,425, of which 1,125 belong to Arcanum alone. The industries of this group consist of three saw and planing mills, two flour mills, a creamery and a cider press.

Stillwater River.

Covington. Population 1,791. This village has neither a public water supply nor a sewer system. Vaults are usually very shallow on account of the nearness of the rock to the surface, and the surface drainage after rains must carry off much objectionable matter.

The local industries consist of a creamery, woolen mill, flour mill, lime kilns, stone quarries, and tile and brick yards. Private wells are 8 to 10 feet deep, most of them drilled into the rock.

Greenville Creek. In addition to the city of Greenville this creek drains the villages of Bradford, Gettysburgh, New Harrison, Weaver's Station, Palestine, Coleville, Hillgrove, and Bartonia; the latter in Indiana. Bradford has a population of 1,254, and the remaining number a total population of about 1,000. The industries consist of the railroad shops at Bradford and several saw mills, flour mills, a cider press, cane mills, etc., scattered through the district. A number of these are run by water power furnished by Greenville Creek.

Greenville. Population 5,501. This city, the county seat of Darke County has an excellent public water supply and one of the best sanitary sewer systems in the watershed. It is estimated that 80 per cent. of the people have access to this system, but on account of its newness only 200 people as yet have the use of the same. The sewage is at present discharged through one outlet sewer direct into Greenville Creek. The surface drainage is cared for by gutters and the few old combined sewers which were in place, supplemented by one new line.

Vaults are required to be water-tight but very few comply with this regulation, especially the old ones. Night soil and garbage are disposed of individually on the neighboring farms.

The industries consist of a few saw mills, tile mills, and machine shops. The private water supply is obtained from wells dug about 25 feet into the gravel found below the surface soil and clay.

Darke County Infirmary. Population 80. This institution is located a few miles south of Greenville and its sewage and surface drainage go to a branch of Greenville Creek. It is estimated that some 60 of its occupants use sewered closets. The water supply is obtained from two 80 foot driven wells. Pressure is obtained by pumping the water together with a certain amount of air to a horizontal steel tank where the air is compressed, forcing the water through the pipes when the pumps are not running.

Stillwater Creek. Above Covington this stream drains one of the most level sections of the watershed. In addition to Versailles this district contains the following villages: Horatio, Bloomer, Webster, Dawn, Frenchtown, Beamsville, Stelvedio, Pikeville, Ansonia, Woodington, Hagerman, Rossville, New Weston, Burketsville, and Lightsville; the combined population of which is some 2,700, with 676 for Ansonia, the largest of the group.

The industries of these villages consist of a large number of saw mills and hoop, handle and stave factories, one or more for each village, with the addition of a few flour mills, tile mills, cider presses, etc.

Versailles. Population 1,478. This village is now putting in a water works, the supply to be obtained from a number of driven wells in the valley of Swamp Creek. The public water supply was badly needed as the water from the shallow private wells was of poor quality.

There are as yet no sewers in use; storm water is cared for by ditches and gutters. Vaults are but rarely found, shallow pits, boxes, etc., being used almost entirely. Garbage and refuse are dumped in several low places near the village, caused by the excavation of gravel for railroad work.

The industries consist of a creamery, cider press, two saw mills and a chicken packing house.

Darke County Children's Home. Population 70. This Home is north of Greenville, with its drainage going to a branch of Stillwater Creek. About 40 of its residents have the use of sewered closets, the remainder using vaults. It will be noted that the drinking water is obtained from a shallow dug well, while the water for general use comes from a number of deep driven wells.

Great Miami River. Just above Dayton the river receives the drainage from Chambersburg, Vandalia, West Charleston, and Ginghamsburg, the total population of which is 660, and whose industries consist of a few saw mills.

Honey Creek. On this watershed are the villages of Miami City, New Carlisle, and Addison; the total population of which is 1,470, with 995 of this for New Carlisle. Among the industries are two flour mills and several saw mills and planing mills.

Lost Creek. In addition to the County Children's Home this stream drains Casstown, Fletcher, and Lena; the total population of which is 790, and for which three saw mills constitute the total industries.

Miami County Children's Home. Population 71. The drainage from this place it drains to Lost Creek. It is estimated that the average number of its residents using sewered closets is 21, the remaining 50 using out-door vaults. The water supply is from a number of dug wells, located some distance from the buildings.

Great Miami River.

Tippecanoe City. Population 1,703. This village has a public water supply and a number of combined sewers which empty into the Miami and Erie canal. It is estimated that about 20 percent of the people have access to these sewers, but as yet they are used by only some 25 persons. The old vaults are merely holes in the ground, but the new ones must be water-tight. Garbage and night soil are dumped in an old gravel pit south of town and also along the canal.

The industries consist of a bent works, two whip factories, strawboard works, furniture factory, and the usual saw mill and flour mills; the latter run by water-power from the canal. A distillery is now being put in and will soon be in operation. Nearly all of the industrial wastes are sent to the canal. Private wells are from 5 to 25 feet deep, plenty of water being found in the gravel under the surface soil.

Troy. Population 5,581. This city, the county seat of Miami County, has a public water supply and a few short combined sewers. It is estimated that some 15 percent of the people have access to the sewers, and that some 850 people have the use of the same when the large number of private sewers are included. Vaults are constructed in any and every way, but must be cleaned out as necessary. Garbage and dead animals are buried in a sandy island below town, and garbage is dumped here and along the river.

Among the industries of this place are two distilleries, two breweries, several quite large slaughter houses, and a number of carriage and wagon factories; also dash and pole and shaft works. A flour mill below town is run by water-power from the river.

The private water supply is from shallow wells, both dug and driven into the gravel found through this whole section.

Miami County Infirmary. Population 75. This institution is located just north of Troy and only a short distance back from the river. On an average 60 of its residents have access to closets sewered direct to the Great Miami River. The water supply is from a shallow driven well.

Piqua. Population 12,172. The public water supply for this city is obtained from the "hydraulic" and is not used for domestic purposes. For this use water is obtained from private wells, a large number of which are dug from 15 to 30 feet into the gravel and a few are drilled 35 to 40 feet deep, getting into the limestone below the gravel.

Piqua has the separate system of sewers with about 30 percent of the people accessible to the sanitary system, and with some 600 persons having the use of the same. The sanitary sewers lead to one outfall sewer which empties into the Great Miami direct. Vaults are required to be water-tight, but the regulation is not enforced. A school house even has put in a cesspool which reaches the same gravel strata from which the drinking water is obtained only a short distance away.

The principal industries consist of four woolen mills, two straw-board works, three linseed oil mills, two breweries, a malt house, creamery, rolling mill, stove works, several large slaughter houses, and a large amount of general manufacturing. The industrial wastes go both to the canal and to the river, and cause a nuisance in both at times.

Loramie Creek. The head-waters of this stream are impounded in Loramie reservoir for the supply of the Miami and Erie canal. Besides the village of Minster there are on the watershed the smaller villages of Lockington, Houston, Dawson, Russia, Wyant, Loramie, Osgood, Yorkshire, North Star, and Botkin. These have a total population of something over 1,800 and their industries consist of eight saw mills, three creameries, a flour mill, and a few tile mills.

Minster. Population 1,465. The surface drainage of this village goes to the canal and to a creek leading to the canal. As there are no sewers these same waterways receive the drainage from the various manufacturing establishments, among which are a creamery, two shoddy mills, two barrel factories, a flour mill, machine shop, etc.

Water is obtained from shallow wells dug in the gravel, and from deeper wells drilled to rock.

Great Miami River.

Shelby County Infirmary. Population 47. This infirmary is three miles southwest of Sidney, and its surface drainage and sewerage are to Rock Run, a small tributary of the Great Miami. It is estimated that about 30 of its residents use sewered closets. The water supply is from three wells from 98 to 105 feet deep.

Sidney. Population 5,688. This city has a public water supply but as yet only a few short sewers, though a complete sanitary system is under way. To the present sewers, which empty into the Great Miami

River, it is estimated some 15 percent of the people have access, but only about 530 persons are now using the same. The construction of vaults and cesspools is not regulated and the many in existence cannot help but be a nuisance to the few shallow private wells still in use. The local industries consist of a brewery, tannery, two hollow-ware plants, and a number of general manufacturing plants making brooms, carriages, poles and shafts, flour, scrapers, whips, etc.

Shelby County Children's Home. Population 47. This Home is located just east of Sidney on the high ground overlooking the Great Miami River. Every one has access to closets, sewered direct to the above named stream. The water supply is obtained from the Sidney water-works and from a spring.

Mosquito Creek. This creek enters the Great Miami at Sidney, bringing in the drainage from Plattsville, New Palestine, Rosewood, and Carysville. The total population of these is 450, and their industries consist of a few saw mills and a creamery.

Plumb Creek. On the watershed of this stream are the villages of Swanders and Anne, the combined population of which is 750, and whose industries include a number of saw mills, a creamery, and a flour mill.

Great Miami River.

Port Jefferson. Population 355. This is a quiet old village located at the head of the feeder which joins the canal at Lockington. Its only industry consists of a saw mill.

Pemberton. Population 250. Little Indian Creek carries the drainage of this place a short distance to the river. Among its industries are a grain elevator, saw mill, and cider press.

Quincy. Population 642. The industries supported here are a water-power flour mill on the river, a handle factory, saw mill, and creamery.

Stony Creek. A few miles back from the river there is located on this stream the village of Spring Hill. Population 157. Some of the surface drainage at Bellefontaine also reaches this stream.

Great Miami River.

De Graff. Population 1,150. This village has as yet neither a public water supply nor a sewer system. On account of the large number of shallow pits and boxes used as vaults the surface drainage is no doubt objectionable after rains. Water is obtained from private wells, both dug and driven from 20 to 80 feet into the gravel.

Buckinjahalis Creek. This stream drains both the county infirmary and children's home, and also a portion of Bellefontaine.

Logan County Children's Home. Population 46. This institution is located one and one-half mile west of Bellefontaine. The waste from the laundry, kitchen, and several closets, accessible to perhaps ten of the residents, is carried direct to the creek. The water supply is obtained from wells driven from 40 to 53 feet deep.

Logan County Infirmary. Population 68. This infirmary is located on Flat Branch Creek, a tributary of the above, some three and one-half miles northwest of Bellefontaine. Its drainage, together with the sewage from closets accesible to only eight persons, goes direct to the creek. The water supply is also from driven wells 30 to 40 feet deep.

Bellefontaine. Population 6,649. This village has a public water supply but no sanitary sewers whatever, and only a few short storm-water drains. The surface drainage goes to both Buckinjahalis and Stony creeks. It is claimed that there are a few water closets connected with the storm sewers, but the majority in use drain to cesspools. Vaults and cesspools are dug down to gravel, but they must be cleaned out when necessary, and the contents disposed of on farms.

Among the industries are the railroad shops, three carriage factories, a saw mill, creamery, and the ever present slaughter house, the latter being out of the city however.

Private wells are being abandoned for the city water, those in use, however, are both dug and driven into the gravel found just below the surface.

Great Miami River.

Loganville. Population 150. No industries.

Hodge Creek.

On this stream is the village of Maplewood, the population of which is 200, and whose industries consist of a tile mill, saw mill and grain elevator.

Wolf Creek.

On this watershed are the villages of Bloom, Sante Fe, Geyer, Jackson Center, Montra, New Hampshire, and Waynesfield. The total population is about 2,200, and their industries consist of a large number of saw mills and stave mills, also a planing mill, three tile factories, a flour mill, creamery, and excelsior factory.

Great Miami River.

The head-waters of the main stream are impounded in Lewistown Reservoir for the supply of the Miami and Erie canal. On the watershed are the villages of Lewistown, Lake View, Huntsville, New Richland, and Belle Center. The combined population of these is about 2,180, and their industries consist of several cider presses, saw mills, and stave factories, also a creamery, shoe factory, stirrup factory, tile and brick works, etc.

b. LITTLE MIAMI RIVER.

Tributary direct to the Little Miami River in some of the surface drainage of the extreme eastern part of Cincinnati.

Mt. Washington. Population 781. This village is located on the hills east of the river, with its drainage reaching the latter by the way of several small runs. Its only industry seems to be a canning factory.

Duck Creek.

This overburdened stream brings into the Little Miami River the sewage from a large number of the suburbs of Cincinnati, and some of the storm drainage of that city.

Madisonville. Population 3,140. This village has a public water supply but as yet no sewer system. Its surface drainage is to the east fork of Duck Creek. Many water-closets drain to cesspools which, with most of the vaults, are dug some 10 feet deep and walled up. When full many of these are cleaned out but a number have been covered over and new ones dug. The only industry is a planing mill, many of the inhabitants being employed in Cincinnati. The private water supply is from wells dug from 45 to 75 feet deep.

Madeira. Population 125.

Kennedy Heights. Population 209.

Silverton. Population 250.

Pleasant Ridge. Population 953. About half of the population of this village drains to Duck Creek.

Oakley. Population 528. This village has been piped for water to be supplied from the Cincinnati works, but the connection has not been made as yet. A number of streets were recently paved and a few short storm sewers put in.

Norwood. Population 6,480. Only half the population of this village is tributary to Duck Creek. Norwood has a public water supply and an extensive system of both sanitary and storm sewers. On the Duck Creek side it is estimated that about 75 percent of the people have access to the sanitary sewers and that they are used by some 1,600 persons. No new vaults are allowed and every house is supposed to be sewered, though of course there are a large number of the older ones which are not as yet connected. Garbage is disposed of individually by dumping in any convenient place away from the city. The industries consist of a large playing card factory, electric supplies factory, washing machine factory, furniture factory, and tool works. There are only a few private wells now in use.

Hyde Park. Population 1,691. It is estimated that about 1,000 people of this village are in the Duck Creek drainage area. The village is supplied with water from Cincinnati, but has no sewers except storm water drains. A private sewer to Duck Creek is used by some 250 people. The village is a residence district for Cincinnati and has no industries.

Evanston. Population 1,716. About 1,000 people in this village are tributary to Duck Creek. The public water supply is obtained from Cincinnati but in contrast to Hyde Park this village has a complete system of sanitary sewers. It is estimated that about 95 per cent. of the population have access to these sewers and that they are used by some 375 people.

Dairy Farms. Along Duck Creek there are a number of large dairy farms from which a large amount of very objectionable drainage reaches this stream.

Little Miami River.

Up to the entrance of the East Fork the river receives the drainage of Newton, Plainville, Terrace Park, and South Milford, the combined population of which is some 1,200, and whose industries consist of two water-power flour mills at Plainville.

East Branch of the Little Miami River.

This stream drains a larfe hilly section of the watershed, including portions of Clermont, Brown, Highland, and Clinton counties. On this area there are a large number of very small villages, which have no industries whatever and which for all purposes of this investigation can be ignored.

Perrinville. Population. 150. No industries.

Stone Lick Creek.

On this stream are the villages of Boston, Monterey, Newtonville, and Edenton, the combined population of which is 700, and whose industries consist of small flour mills.

East Branch of the Little Miami River.

Clermont County Infirmary. Population 75. This institution is situated on the "Branch" only a few miles below Batavia. About 50 of its residents have the use of closets sewered to a cesspool which overflows to the above mentioned stream. The main building is built on rather low ground making it difficult to carry the sewage away. The water supply is obtained from springs and a shallow dug well.

Batavia. Population 1,029. This city has a public water supply, just recently introduced, and a number of storm sewers emptying into the river. Vaults are usually very shallow and seldom cleaned out, new ones being dug as required. The bulk of the water used for domestic purposes is taken from private wells dug from 25 to 50 feet through the clay and into the gravel below. The only industries are a brick and tile works, and a small water power grist mill.

Above Batavia the watershed consists of a long and narrow strip of territory extending up nearly to Fayette County. In this area are the villages of Williamsburg, Lynchburg, and New Vienna, and a host of smaller places, among which are Amelia, Marathon, Fayetteville, St. Martin, Westboro, Midland, Dodsonville, and Martinsville. The total population of these smaller villages is 3,350, and their industries include a number of flour and saw mills, a canning factory, a tile mill, etc.

Williamsburg. Population 1,000. This is a quiet old place in the midst of the hills of Clermont County. In addition to its numerous stores with which to supply the wants of the neighboring farmers it has a flour mill and two chair factories.

Lynchburg. Population 907. This village has a public water supply but no sewers whatever. Its surface drainage and the wastes from its industries go direct to the creek. Vaults are but seldom dug, boxes being used almost entirely. The private water supply is from shallow wells dug into the surface strata of sand and gravel. The industries consist of a large distillery, a brick and tile mill, and a saw mill. The distillery runs from October to July and makes up into whiskey some 750 bushels of corn a day for the above season. The refuse from the stills is fed to steers, some 1,000 of which are kept for this purpose. The animals are being fattened for the market and so are kept confined in small pens. The drainage from these is led to a pond or settling basin from which the liquid portion is run to the river and the solid parts used for fertilizer. At times all of this refuse is sent direct to the creek. The whole establishment is dirty and foul-smelling in the extreme and the creek is polluted for miles, and to such extent that fish cannot live. No serious complaint seems to be made as the plant is the life of the town.

New Vienna. Population 805. This village is situated at the very headwaters of the East Branch. Its industries consist of two flour mills, two saw mills, creamery, cider press, and stone quarry.

Little Miami River.

From the East Branch to Loveland this river receives the drainage of Terrace Park, Milford, Camp Dennison, Miamiville, Remington, Montgomery, Hazlewood, and Symmes. The total population of these is some 2,700, with 1,159 for Milford, the largest of the group. The industries of these places include a number of flour mills and saw mills and a canning factory.

Loveland. Population 1,260. There are a number of storm drains from this village to the river which carry a considerable amount of kitchen and some closet drainage, causing a nuisance at times. As there is no public water supply a number of places are provided with the means for storing rain water with which to flush the closets.

The industries consist of a large creamery, flour mill, canning factory ,etc. The water for domestic use is obtained from shallow dug wells and from cisterns.

Obanon Creek.

This stream brings in the drainage from Goshen, a small village of some 250 people and Cozaddale, with only 50 people, but at the latter place there is a creamery.

Little Miami River.

Between Loveland and Morrow the river receives almost directly the drainage from Fosters, Miamiville, King's Mills, and Deerfield, and less directly that from Mason. The combined population of these is some 2,100, and their industries consist of a number of flour mills, saw mills, and canning factories, the latter at Deerfield; also a large powder and cartridge factory at King's Mills. There is an abandoned salt well at Mainville.

Turtle Creek.

Lebanon. Population 2,867. This village, the county seat of Warren County, has both a public water supply and a few short combined sewers. It is estimated that 5 per cent. of the people have access to these, but as yet they are in use by only 30 persons. New vaults are required to be water-tight but old ones are constructed in the usual unsanitary manner. Private wells are usually dug from 12 to 60 feet deep. The industries consist of a flour mill, saw mill, and creamery.

Warren County Children's Home. Population 40. This institution is located a short distance west of Lebanon, and is supplied with water from the water works of that village. All of the occupants have access to closets sewered direct to Turtle Creek.

Warren County Infirmary. Population 110. This infirmary is situated here on high land across Turtle Creek from Lebanon. It is supplied with water from the Lebanon water works and from two dug wells. Its entire population has access to closets sewered to a cesspool which drains and overflows to the creek.

Little Miami River.

Morrow. Population 869. This village is situated at the confluence of Todd's Forks and the Little Miami River. Its industries consist of a creamery, brewery, saw mill and flour mill, the latter run by water power obtained from the river.

Todd's Fork.

In addition to Blanchester, Wilmington, and the Clinton County Homes, this watershed contains the villages of Pleasant Plain, Butlerville, Clarksville, Cuba, New Antioch, and Ogden. The total population of these latter is something over 1,200, and their industries consist of several saw mills, two flour mills and a pickle factory.

Blanchester. Population 1,788 This village has a public water supply, but the water is not fit for domestic use; shallow dug wells and cisterns furnish water for this use. The village has neither sanitary nor storm sewers. A number of buildings are provided with water closets sewered to cesspools and some of which overflow to Second Creek, a branch of Todd's Fork. As a rule all vaults and boxes are cleaned and the contents taken to the country.

The industries consist of two hame factories, tile mill, creamery, canning factory, machine shops, saw mill, and flour mill.

Wilmington. Population 3,613. This large village has neither a public water supply nor sewer system. There are a few private sewers, from houses and buildings, which empty into a small run causing a nuisance at times. Boxes are in general use in preference to vaults, and they are usually kept clean. Night soil and garbage are disposed of on the neighboring farms. The local industries include a bridge works, auger bit works, shoe factory, flour mill, saw mills, creamery, slaughter houses, etc. The water supply is from private wells dug from 20 to 25 feet into the gravel, a few going 50 to 60 feet into the shale and limestone.

Clinton County Children's Home. Population 27. This house is situated just west of Wilmington. It is not provided with a sewer of any kind, and its water supply is obtained from an ordinary dug well; in every way it is like a large farm house.

Clinton County Infirmary. Population 94. This institution, situated just east of Wilmington, is provided with a sewer for kitchen and laundry drainage only. All the occupants use unsewered closets. The water supply is from shallow dug wells.

Little Miami River.

Fort Ancient. Population 50. This place is interesting from the fact that on the hills above it, overlooking the river, there is a very fine and extensive example of the prehistoric earth-works.

Freeport. Population 120. There is located here a good water power flour and saw mill, and a bridge works.

Caesar's Creek.

On the watershed of Cæsar's Creek there are the villages of Harveysburg, New Burlington, Paintersville, Lumberton, Port William, Bowersville, Bloomington, New Jasper, and Jamestown. The total population of these is about 3,000, of which 1,205 belongs to Jamestown The industries consist of a large number of saw mills, several flour mills, and one or two creameries and tile mills.

Little Miami River.

Waynesville. Population 723. This village is now putting in a public water supply. At present the water for domestic use is obtained from shallow wells dug down through the soil and gravel to the rock. A few water tight vaults are in use but the majority consist of very shallow holes, nearly all of them are cleaned, however. The local industries consist of water power flour mill and saw mill, a creamery, and wood-working shop.

Corwin. Population 131. This village is just across the river from Waynesville and is the railroad station for that place.

Mt. Holly. Population 175. There is a small flour mill and distillery here.

Spring Valley. Population 522. This village supports quite a large flour mill and a few saw mills.

Sugar Creek.

This small stream drains Bellbrook, Centerville, and Beavertown, the combined population of which is 800, and whose industries consist of a few saw mills only.

Beaver Creek.

On the watershed of this stream are the villages of Alpha and Zimmerman, the total population of which is some 250. Each place supports a small water power feed mill.

Little Miami River.

Trebeins. Population 40. There is located here a large flour mill operated by water power obtained from the river.

Shawnee Run.

Xenia. Population 8,696. This city, the county seat of Greene County, has a public water supply but as yet no sewers except a few short combined ones, put in originally for storm water only. A new system of sanitary sewers has been planned, including an intermittent filtration disposal works, and it is expected that these will be put in during 1901. To the present sewers it is estimated that 10 percent of the population has access and that they are used by some 60 persons. There are quite a number of water-closets in use which are sewered to cesspools, some of which may drain to the sewers.

The law requires that vaults be water tight though but few of the older ones are so constructed. Many old vaults have been abandoned and covered over without cleaning. Garbage is fed to hogs, many of which are kept in town. The industries include a strawboard works, an old brewery, shoe factory, five cordage works, and the usual saw, flour, planing and tile mills.

There are a number of private wells still in use though they are gradually being abandoned in favor of the city's supply.

Ohio Soldiers and Sailors Orphans' Home. Population 1,010. This large institution is situated just southeast of Xenia on Shawnee Run. It has its own water supply, and a sewer system to which are connected water-closets accessible to all the occupants of the Home. The sewage is supposed to be pumped to settling pits in the rear of the buildings, but the pump is too small to handle all of it and some overflows from the collecting well to Shawnee Run, causing a much complained of nuisance. The settling pits are not properly cared for and offer but little chance for sedimentation. The overflow from these goes to Gladys Run which enters the Little Miami River at Spring Valley.

Little Miami River.

Greene County Children's Home. Population 36. This Home is located a few miles northwest of Xenia on a small run going direct to the river. The waste from the kitchen and laundry is led to this ravine but the sewer carries no water-closet drainage. The water supply is obtained from a spring.

Greene County Infirmary. Population 100. This institution is northwest of Xenia near the Children's Home. All its occupants have the use of water-closets sewered to a ravine leading to the river. The water supply is obtained from a well and a spring.

Massick's Creek.

In addition to Cedarville this stream drains the villages of Wilberforce, Selma, and Grape Grove. The total population of these is 550, and their industries consist of a few saw mills and tile mills.

Wilberforce College. Attending this school are some 330 students, with 27 officers and instructors. The latter, only, have access to water-closets sewered to the creek, the others using out-door vaults. Water is supplied from a number of springs.

Cedarville. Population 1,189. This village has quite a number of industries, among which are a strawboard works, water power flour mill, two saw mills, stone quarry and lime kilns, tile works, brick yards, etc. As the rock is very near the surface vaults are as a rule shallow, but are kept cleaned out. The water is obtained from private wells dug 30 to 40 feet in the rock. The refuse from the strawboard works is carried in a flume some distance below town and is emptied into a five acre reservoir. This is supposed to intercept all suspended matter and prevent the usual nuisance in the creek, but it does not seem to be a success.

Little Miami River.

Goe's Station. Population 300. The industry of this place is a quite extensive powder mill.

Yellow Springs. Population 1,371. The sole support of this village is the educational institution located here, Antioch College. Neither the village nor the college has a water supply other than private wells, or any sewers whatever.

Clifton. Population 262. There is quite a picturesque water power flour and saw mill located here.

South Charleston. Population 1,096. The industries of this place include a saw mill and tile mill, a flour mill and a creamery. There are three short sewers in the village for cellar drainage only. Vaults are usually very shallow and many are covered over instead of being cleaned out. The water supply is from private wells both dug and drove, some 15 to 20 feet through the surface soil and clay into the gravel and quicksand below.

2. SEWERAGE OF CITIES AND VILLAGES HAVING PUBLIC WATER SUPPLIES.

In this section there has been collected the general details of the sewer systems previously referred to, also a tabular statement is given for convenience in reference and comparison. In a few cases the table will give all the information that there is to give and no further mention of these will be made in the text.

Batavia has but recently introduced a public water supply and sewage can be expected from this village in the near future.

Bellefontaine is one of a number of towns in this watershed that are situated so near the head-waters of the stream to which they are tributary that it is impossible to dispose of any quantity of sewage by dilution alone and some method of purifying the same must be secured along with the introduction of a sanitary or combined system. It is contrary to an ordinance to send house drainage to the storm sewers, but it is generally understood that some is disposed of in this way.

Dayton was until 1890 supplied with a very inadequate system of combined sewers. During the above year a sanitary system was designed for the city and work at once started to install the same and turn the old combined sewers into a storm water system. Now there are 47 miles of sanitary sewers in, with six additional miles under construction. It is estimated that 30 percent of the total population have access to the sanitary sewers, now in place, and that 18 percent have the use of the same. This latter figure was arrived at from the fact that there are 1,700 connections to the sewer system and 2,832 water-closets on the water works mains. The sanitary sewers all lead to one outlet sewer which empties into the Great Miami River, in the lower part of the city, at a point opposite the waste way from the hydraulic and two of the large storm sewers. The sewage causes a local nuisance in times of extreme low water, but there seems to be no cause for complaint on this account as the outlet is removed from the immediate vicinity of dwellings. During high water, in order to discharge the sewage into the river, it is necessary to lift it some 16 feet, for which purpose a 20,000,000 gallon pumping plant has been installed. This consists of two 12-inch centrifugal pumps, actuated by two 40 horse-power steam engines, with each pump and engine so arranged as to work interchangeably as a safeguard against a complete failure of the plant from accident. The six miles of sanitary sewers which are now under construction are in the northern part of the city in low lying ground from which, in order to carry the sewage to the present system, it will be necessary to lift the same some five feet. This small head is to be overcome by two Shone ejectors, which will be operated by compressed air furnished from the .water works pumping station. There are about 50 miles of storm water sewers in, covering practically the whole city and emptying at the most convenient points into the Great Miami, Stillwater and Mad rivers, the Miami and Erie canal, the hydraulic, and various creeks and ditches. It is stated that there are still a number of house connections to these sewers, it being almost impossible to get every drain diverted to the sanitary system.

Evanston has both storm and sanitary sewers emptying into both Bloody Run and Duck Creek, the latter only a tributary of the Miamis. In the whole village there are six miles of sanitary sewers, which are accessible to some 95 percent of the people and are in use by 29 percent. While in the area within the Little Miami watershed, there are 3.4 miles of sanitary sewers which give 95 percent of the population in the area access, and are used by some 37 percent of the same portion of the total population. The sewage sent to Bloody run adds to the general filth of the Mill Creek valley and that portion going to Duck Creek causes more or less of a nuisance during the summer and fall.

Franklin. The few short sewers in this village were originally put in for storm purposes only, but the construction of the water works favored the introduction of baths, water-closets, etc., the easiest drainage for which were the storm sewers already in place.

Greenville is now completing one of the best sanitary sewer systems in the district. It has already completed 12 miles of sewers with 4.5 under way, which, when completed, will give some 80 percent of the people access to the same. There are at the present time, however, only 30 connections to the system, representing a very small percent of the population, but it is expected that during the coming year there will be a large increase in the above number. For three years the sewage is to be discharged direct to Greenville Creek, but after this time purification will be required, as it was thought that by the time this period should elapse there would be discharged into the creek a quantity of sewage sufficient to cause a nuisance.

Hamilton also has a good system of sanitary sewers, with three outlets to the Great Miami River. Here also, as in Dayton, during exceptionally high water it is necessary to raise the sewage from the main outlet sewer, some 16 or 17 feet in order to discharge it into the river.

For this purpose there has been installed a pumping plant consisting of two 12-inch centrifugal pumps actuated by two steam engines. The plant has a capacity of some 15,000,000 to 20,000,000 gallons daily, and has been in use but twice, in the month of February of 1897 and 1898. In all there are 18.8 miles of sanitary sewers in, giving some 65 percent of the total population access to them. It is estimated that some 4,700 people, or 20 percent of the total number, have the use of the sewers.

Hyde Park. The surface drainage of Hyde Park goes both to Crawfish Creek and to Duck Creek. There are no sanitary sewers in and all house drainage is to cesspools or through private sewers to the creek. It is estimated that in the latter way Duck Creek receives the drainage from some 50 houses. This sewage causes a nuisance in warm weather and is much complained of.

Lebanon has a few short combined sewers, originally intended for storm water only, which carry from a few houses enough sewage to cause more or less nuisance in Turtle Creek, a very small stream. This village belongs to the list of towns in which purification will be required for the discharge from any extensive system of sanitary sewers.

Madisonville. Attention must be called to the total lack of sewerage in Madisonville, one of the numerous villages serving as a resident place for workers in Cincinnati. This village contains a large number of very fine residences in which, according to the water-works books, there are only 49 water-closets. All these drain to cesspools, as there is no system whatever of sanitary drainage.

Middletown. About 30 percent of the population of Middletown have access to some 7.2 miles of combined sewers. This system has five outlets to the Great Miami River into which the sewage is emptied with but little nuisance on account of the great dilution.

Norwood is within the drainage areas of both Bloody Run and Duck Creek, and its storm and sanitary drainage is to both streams. In the whole city there are 22 miles of sanitary and five miles of storm sewers, to the former of which some 60 percent of the population is accessible and 43 percent has the use of. In the area within the Little Miami watershed there are 14.0 miles of sanitary sewers and 2.5 miles of storm sewers. It is estimated that one-half of the total population is on the Duck Creek drainage area and that 75 percent of these have access to the sanitary sewers draining to Duck creek, and that some 50 percent of the same have the use of the sewers. The sewage emptied into Duck Creek causes a very objectionable nuisance for the greater part of the summer and fall.

Piqua has the separate system of sewers with some 4.4 miles of sanitary sewers and 3.0 miles of storm sewers now in place. About 30 percent of the total population has access to the sanitary sewers, but only one-sixth of these, or 5 percent of the total, have as yet taken advantage of them.

Sidney has quite a number of combined and semi-private sewers leading to the Great Miami River, which are made use of by some 6 percent of the total population. These drains have given rise to much complaint on account of the nuisance caused by them and it is intended to install a new sanitary system. In order to further this much needed improvement permission has been given by the Board to send the sewage direct to the river until such time as purification shall be required on account of a nuisance or other proper consideration.

Springfield has 10 miles of combined sewers to which it is estimated that some 20 percent of the city's population have access and some 8 percent the use of. These sewers empty through 12 outlets into Mill Creek and Buck Creek, both small streams, where during the warm months the sewage stagnates and causes a very objectionable nuisance. Just above the confluence of Mill Creek and Buck Creek there is, in the former stream, a dam which impounds a large part of the sewage, causing a most foul nuisance, nearly in the center of the city. This same creek, Mill Creek, runs through the heart of the city, being arched over in places, and receives filth of every description, which its very small flow is not able to carry away, adding further to the nuisance. It seems that according to the local ordinances Springfield has only storm sewers and that house connections are not allowed to be made to the drains, certainly a relic of its childhood. This law, as seen, is not observed, even the city building being connected to one of the so-called storm sewers. The facilities for collecting and disposing of sewage in this, the eighth city of the state, can be considered nothing short of disgraceful.

Tippecanoe City has a few short combined sewers, emptying into the Miami and Erie canal, which, while they are accessible to quite a percent of the population, are but little used for house drainage.

Troy is traversed by three waterways which receive the drainage from a few short combined sewers and from a very large number of private sewers. With these latter included it is estimated that some 25 percent of the population are accessible to the sewers and that 15 percent have the use of the same.

Urbana. There is no means for the disposal of house drainage except by private cesspools. It is hardly necessary to state that in a city of this size and furnished with a public water supply, this condition cannot help but be objectionable and that a sanitary sewer system should be put in at once.

West Alexandria also has no sanitary sewers and all water-closets have to be drained to cesspools, but on account of the small number in use it is not as yet as objectionable as in a larger place.

West Carrollton. None of the houses of West Carrollton have as yet been provided with the so-called "modern conveniences."

Xenia has 1.2 miles of sewers designed at first for storm-water only, but now carrying house drainage, which empty into Shawnee Run and its tributaries, causing a very objectionable nuisance. A complete sanitary system has been designed for this city which will shortly be put in.

The outfall sewer is to be carried below the city in the valley of Shawnee Run, where intermittent filtration beds are to be put in for the purification of the sewage before turning it into the run.

It will be noted that the storm drainage of a small portion of Cincinnati goes to Duck Creek, but it is not believed that any considerable amount of sewage reaches that stream from this city.

Of the 29 cities and villages given in Table 4 as having public water supplies, eight have no sewers whatever, seven have a few storm water drains only, eight have a more or less extensive system of combined sewers, and six have the separate system of sewers, with, in this case, the sanitary system quite well developed. The sewage is disposed of in every case by dilution alone.

In all there are 67.7 miles of storm sewers, or an average of 6.2 miles for each of the 11 places for which the mileage could be secured.

Of the combined sewers there are 23.0 miles, an average of 2.9 miles for each of the eight given, while for the sanitary there are 104.1 miles, an average of 17.4 for each of the six given.

For the fifteen towns, including Hyde Park, which have sewers for house drainage, the average percent of the total population accessible to these sewers is 36. In these same towns it is estimated that the total number of closet connections to the sewers is 4,197, representing some 29,140 people, or an average of 280 connections and 1,943 people for each town. The average percent of the total population using the sewers is 14.

Of the total population in these 29 cities and villages, 207,187, or 87 percent, live in those having more or less extensive systems of combined or sanitary sewers, while 30,575, or 13 percent, live in those which have as yet no sewers for carrying off house drainage. In all there are 67,148 people living in houses accessible to the sewers, which is 33 percent of the total population of the sewered towns. There are of those who actually have the use of sewers only 29,140, or 12 percent of the total population, and 14 percent of the population of the sewered towns. Thus it is seen that less than one-half of the people so fortunate as to live in houses within reach of sewers have as yet taken advantage of them. After a sewer has been constructed there is much still to be done before the full benefit of the improvement is secured.

Returning to a consideration of the individual systems it appears that in 13 cases, which include the storm sewers of Urbana and the private sewers of Hyde Park, the discharge of sewage into the various streams has caused more or less of a nuisance while in three only has there been no nuisance caused as yet.

The sewage from none of the cities and villages in the Great Miami watershed discharges into a stream from which a public supply is taken, in Ohio. In the Little Miami watershed the sewage from Evanston, Hyde Park, Lebanon, Norwood, and Xenia, affects the water supply of

Cincinnati, which is at present drawn from the Ohio river below the Little Miami. By water, these places are the following distances above the present intake of the Cincinnati water works: Evanston, 16 miles; Hyde Park, 16 miles; Lebanon, 42 miles; Norwood, 15 miles, and Xenia, 76 miles. The emptying of sewage into the streams at Batavia, Blanchester, Lynchburg, Madisonville and Waynesville, would also influence the supply for Cincinnati. These sources of pollution need not be seriously considered, however, as the quantity of sewage is small, the dilution enormous, and the distance very great except in the cases of Evanston, Hyde Park and Norwood; also on account of the fact that the water supply of Cincinnati is much more seriously polluted by the sewage of that city itself, and the fact that a new supply is being developed above all these sources of pollution before mentioned.

The water supply for Batavia is drawn direct from the East Branch of the Little Miami River at a point 47 miles below Lynchburg, but as long as the water is properly filtered there is little danger from the introduction of a sewer system in the latter village, or from the large amount of filth from the distillery and cattle pens which at present enters the stream.

3. SEWERAGE OF ISOLATED PUBLIC INSTITUTIONS, WITH NOTES ON WATER SUPPLIES.

It will take but a brief review of this section in order to appreciate the necessity of including these isolated institutions in any investigation of the sources of pollution of a watershed. On account of a number of large institutions in addition to the usual county homes, it is even more important that they should be included in this study than in any of the former investigations of this character. For many of the institutions all the necessary information is given in concise form in Table 5, and no further mention need be made of these.

As seen, this table notes for each place the source of the water supply for both domestic and general use. Where necessary these notes will be elaborated on in the text following.

Dayton Soldiers' Home. This national home for old soldiers, located one mile west of the Dayton corporation line, has a total population, including officers and attendants, of 4,850. These are housed on the cottage plan with each building heated with steam from a central plant. They are also sewered and provided with water. The water supply is obtained from 16 driven wells, located some distance east of the institution and within the corporation of Dayton. The water is found at a depth of from 45 to 55 feet in a bed of gravel overlaid with hardpan. The well site is surrounded with vaults and cesspools many of which go through the layer of hardpan which is only 12 feet thick. While this condition seems to have caused no trouble as yet, it is certainly an undesirable one and may lead to a serious pollution of the supply. The normal

Missing Page

level of the water in the wells is 35 feet from the surface, and it is lowered but little by ordinary pumping. The supply is pumped direct from the wells to a large open reservoir by two horizontal duplex Smith-Vaile pumps of 1,000,000 gallons capacity each. The reservoir has an area of some 12 acres with an average depth of 20 feet, and serves as a boating course for pleasure parties, a practice certainly to be condemned. Water from fountains, grottoes, etc., also flows back to this lake to prevent wastage. From the lake the water is pumped to a standpipe by a 1,000,000 gallon horizontal compound duplex Smith-Vaile pump and an 800,000 gallon horizontal compound duplex Gordon-Maxwell pump. In this station there is shortly to be installed a new 5,000,000 gallon pump as the present capacity is insufficient. The stand-pipe is 18 feet in diameter, 148 feet high, and has a capacity of 280,000 gallons. The average daily consumption is estimated at 1,600,000 gallons, or 330 gallons per capita of the population of the institution. If the above figures are correct it shows clearly that somewhere there is an enormous wastage of water. Sewered closets are provided for the use of every one on the ground. The waste from closets, buildings, etc., is carried through an 18-inch outfall sewer, four miles long, to the Great Miami River, and there disposed of by dilution. At one time much of the solid matter was disposed of in compost pits, but these have been abandoned as a nuisance.

Dayton State Hospital. This is an asylum for the insane and is located just south of the city limits of Dayton. The average number of inmates is 830, with seven officers and 123 employes. Originally the water supply was obtained from a number of springs, but these became unsatisfactory and in 1896-8 eight 30-foot wells were put down from which the present supply is obtained. The water is pumped direct from the wells to a 90,000 gallon standpipe by a horizontal compound duplex Laidlaw–Dunn-Gordon pump of 1,000,000 gallons capacity and a small Smith-Vaile pump which is little used. The wells do not seem to give a satisfactory water and it is proposed to put down a new set near the old springs. All the buildings are provided with water-closets which are sewered to the Miami and Erie canal, one mile west of the institution.

Miami University. This university is located at Oxford and has an average of 150 students and instructors, none of whom live in the institution proper and only a small percent of whom are present during the summer. The water supply for both drinking purposes and general use is obtained from the village water-works. Formerly much of the drinking water was obtained from a well but this became contaminated, probably from a defective sewer, and its use was prohibited. The buildings are provided with water-closets, the waste from which led into two cesspools. draining to Four Mile Creek. These cesspools or tanks were designed to give purification by the septic process, but they either were carelessly built or have since been so neglected that they cannot be given much credit.

Oxford College. This college, for women, is located at Oxford and has some 135 students and instructors present and living in the institution for the usual school year. Its water supply is obtained entirely from the village water-works. The buildings are fitted throughout with water-closets, which are sewered to Bull Run, a branch of Four Mile Creek. During warm weather this sewage causes a nuisance which is rightfully complained of.

The Western. This college, also for women, is located at Oxford and has attending and living in it some 150 students and instructors. Its water supply for domestic use is obtained from a cistern, while a well near Four Mile Creek supplies the water for general use. The buildings are supplied with water-closets, the waste from which is emptied out on a field draining to Bull Run, a branch of Four Mile Creek.

Oxford Retreat. This is a private sanitarium, having on an average some 70 patients and attendants. It is supplied with Oxford village water for all purposes. It is fitted with all modern conveniences, sewered direct to Four Mile Creek.

Masonic Home. This institution, located just west of Springfield, is supported by private enterprise and has some 160 residents and attendants. Its water supply for both domestic and general use is obtained from a well 40 feet deep. The buildings are fitted throughout with water closets, sewered direct to Mad River.

Knights of Pythias' Home, and Odd Fellows' Home. These are each private institutions, supported by the orders for which they are named. The total number of residents and attendants in each is 136, and 173 respectively. They are both situated on the high ground just north of Springfield and each is supplied with the city water. They are also fitted with all modern conveniences, and sewered direct to Buck Creek; the former, however, through a part of the Springfield system.

Wilberforce College. This is an educational institution for colored youths, and is situated in the village of Wilberforce, Greene County. It has some 357 students and instructors, with the majority of the former living in the institution proper, the remainder in the village around. The water supply for the college is pumped from a spring and distributed through the buildings. Indoor water-closets are provided for the officers only, some 27 persons, while the students use unsewered closets.

Ohio Soldiers and Sailors Orphans' Home. This large institution, situated just southeast of Xenia, has a population of some 1,010 people including officers and attendants. As it is more of a school than a permanent home, the summer population is much smaller than for the remainder of the year. The institution is on the cottage plan, with each building supplied with water, gas, steam, etc., from central plants located on the grounds. The buildings are also provided with sewered closets accessible to inmates as well as officers. The sewage is led to a large cesspool from which it is supposed to be pumped to open pits or beds in the rear of the buildings. These beds are supposed to collect the solid matter and to allow the liquid portion to seep away into the soil. Not only are the beds a failure, but the sewage pump is too small to handle all the sewage and at times much of it overflows to Shawnee Run, where it causes a nuisance much complained of by the residents of Xenia, through which the run passes. Further details of the water supply and sewerage of this institution are given in a special report to be found elsewhere in this volume.

County Children's Homes. Both the inmates and officers of the Champaign, Clark, Shelby and Warren County homes have the use of the sewered closets. In Darke, Logan and Miami County homes the officers have the use of sewered closets at all times, while the inmates use the same during the night only or in bad weather. The Clinton, Greene and Preble County homes are not provided with sewered closets; in fact the Clinton County home does not even have a sewer for waste water. The Preble county home is now being improved and will soon be fitted with modern plumbing. The sewers from the Champaign and Logan County homes are first led to cesspools in which much of the solid matter is collected, the liquid draining to Dugan and Buckinjahalis Creeks. The Champaign and Warren County homes are supplied respectively with the Urbana city and the Lebanon village water, while the others have private water supplies from wells and springs.

County Infirmaries. Only in the infirmaries of Butler, Greene, Montgomery and Warren counties do both inmates and officers have the use of sewered closets, while in all the rest except the Clinton County infirmary, the officers and a portion only of the inmates have the use of such modern conveniences. The sewers from the Champaign, Clermont, Preble, and Warren County infirmaries lead to cesspools, which overflow to the neighboring streams. The Butler County infirmary also sends its sewage to a pit from which much of the liquid soaks away, the remainder going direct to a small tributary of the Great Miami River. If the cesspool is properly constructed and cleaned out when necessary, this method of caring for a small amount of sewage prevents to a certain extent, the nuisance which must always be caused by sending sewage to a stream too small to care for it by dilution.

The Darke, Greene, Logan, and Shelby County institutions send their sewage to small streams and to runs where, for a part of the year, it causes quite a nuisance. The Clarke County infirmary is fortunately situated near a body of water large enough to dispose of its sewage in a satisfactory manner by dilution alone.

The largest of the infirmaries and the one having the only modern method of caring for its sewage is that for Montgomery County. This institution is situated a few miles west of Dayton and at such a distance from the Great Miami River that it would be very expensive to reach that stream with an outfall sewer. A small tributary of the above named river drains the infirmary farm but it is much too small to care for the sewage of 414 people. Plans were prepared by Robert E. Kline, County Surveyor, for an intermittent filtration plant to care for the sewage of this institution, and in June 1899 they received the approval of the Board, and the works were put in during the same year. The sewage from all the building is collected in an 8-inch outfall sewer leading through a screen chamber into a storage reservoir from which it is discharged periodically onto the filter beds by means of an automatic flushing device. The reservoir consists of a covered brick and concrete chamber 14x20x16 feet deep and holding some 12,000 gallons. Before reaching this reservoir the sewage is freed from its coarse suspended matter by passing it through a screen box or basket placed in a circular chamber and so arranged that it can be drawn up and emptied. With the present consumption of water the reservoir discharges once every 24 hours onto the filter beds. There are eight beds now in use, each 50 by 62.5 feet, giving a total effective area of little more than half an acre. The beds contain a 3 to 4 foot layer of filtering material, consisting of a thin layer of screened gravel, then unscreened gravel, and finally a layer of sand. The beds are placed in two rows of four each, with a carrier running in the center of the levee between the rows. From this carrier there leads out over each bed a half tile distributor, portions of which are broken away at intervals so that the sewage may be spread evenly over the surface. To prevent the sand from being disturbed in such distribution there is placed a small slab of stone opposite each opening on which the sewage falls as it leaves the distributor. Each set of beds is underdrained by two long lines of 4-inch tile, each line being placed 12 feet from the sides respectively. The effluent from these underdrains is collected in a 6-inch outfall sewer which empties into the above mentioned run.

As the reservoir discharges only once in 24 hours, each bed has a rest of seven days before it is used again. After the beds have dried off, the attendant rakes over the surface and collects any solid matter which may have gathered on the surface, and dumps it out on the field adjoining the beds.

After the filters were first installed there was considerable difficulty experienced in operating them, owing to the fact that the surface was allowd to become overgrown with weeds to such an extent as to make it almost impassable to the sewage. Since the beds have been raked over after each flooding there seems to have been no difficulty experienced, as the sewage disappears quickly from the surface and appears finally as a well purified effluent.

There is the usual musty odor about the disposal works but not strong enough to be objectionable. The storage reservoir has a decided odor about it, but not a more objectionable one than was coming from some fertilizer stored near it.

For the benefit of the other counties which might wish to profit the good work being done here, it will be said that the disposal works including the sewer, cost, completed, $6,096.65.

The total number of occupants of the miscellaneous institutions is 8,151, of whom all but 330 have the use of sewered closets. It must be remembered that the occupants of a few of these places are present during a portion of the year only, and in one or two cases during a portion of the day only.

The children's homes contain 531 inmates and officers, with 288 using sewered closets and 243 not.

In the infirmaries there are 1,509 people, all but 305 of whom have access to sewered closets.

This makes for all a population of 10,191, of which 9,313 use sewered closets and 878 are not so provided. These institutions are responsible for one-third as much sewage as are all the cities and towns of both watersheds.

In not a single instance does it seem necessary to pollute the streams with the sewage from these institutions. Everything is favorable to the installation of some method of purification; the sewage is small in amount, usually in a concentrated form; it is collected in one outfall sewer; in nearly every case land is plentiful, and usually labor can be had at small or no extra expense.

4. SUMMARY.

In regard to the effect on public water supplies there is little need to summarize the contents of the previous sections.

Batavia has the only permanent surface supply and it is obtained from a stream which is not affected to any extent by sewage, as Lynchburg, the only tributary town with a water supply, is not sewered. The pollution of the stream at this point, by the distillery and its accompanying cattle pens is,, however, very serious, and the Batavia filter plant should be maintained at a high state of efficiency.

The supply for Piqua no doubt receives some sewage from the feeder passing through Sidney, but as the water is so objectionable from other causes that it is not used for domestic purposes this does not matter.

Blanchester has a surface supply which is not potable for other reasons than sewage pollution. Farm drainage and mud are responsible for the poor quality of the water.

The water of Buck Creek with which Springfield helps out its ground-water does not receive any sewage pollution; in fact the stream at the intake does not drain any urban towns. The water during the the low stages of the stream is of fair quality except when compared with the excellent ground water from the gallery. It must be remembered, however, that it comes from a well populated farming district and the chance for serious pollution is ever present. These four constitute all the public supplies obtained from surface sources.

Of the total sewage pollution of the streams it will be seen that both watersheds receive the sewage of some 38,453 people, of which 34,801 belong to the Great Miami watershed, and 3,652 to the Little Miami watershed. The pollution caused by this sewage is cut down a little by the one purification and the several partial purification plants which have been put in.

It must not be thought that the above represents the total sewage population, as there are thousands of cases where the drainage from the vaults of isolated houses and manufacturing establishments is sent to the various water-courses. It is impossible to determine the number of such cases without a house to house canvass, something absolutely out of the question in work of this kind. The wide distribution of this sewage pollution is brought out by the following map, which shows the streams which receive some of this direct sewage pollution.

In the Great Miami watershed it will be seen that there are only 6 streams of any size that are not polluted by sewage.

The Great Miami river above DeGraff escapes, but on the watershed there are the large villages of Jackson Center, Lake View and Belle Center, which, if not at present, will in time be sending sewage to the stream.

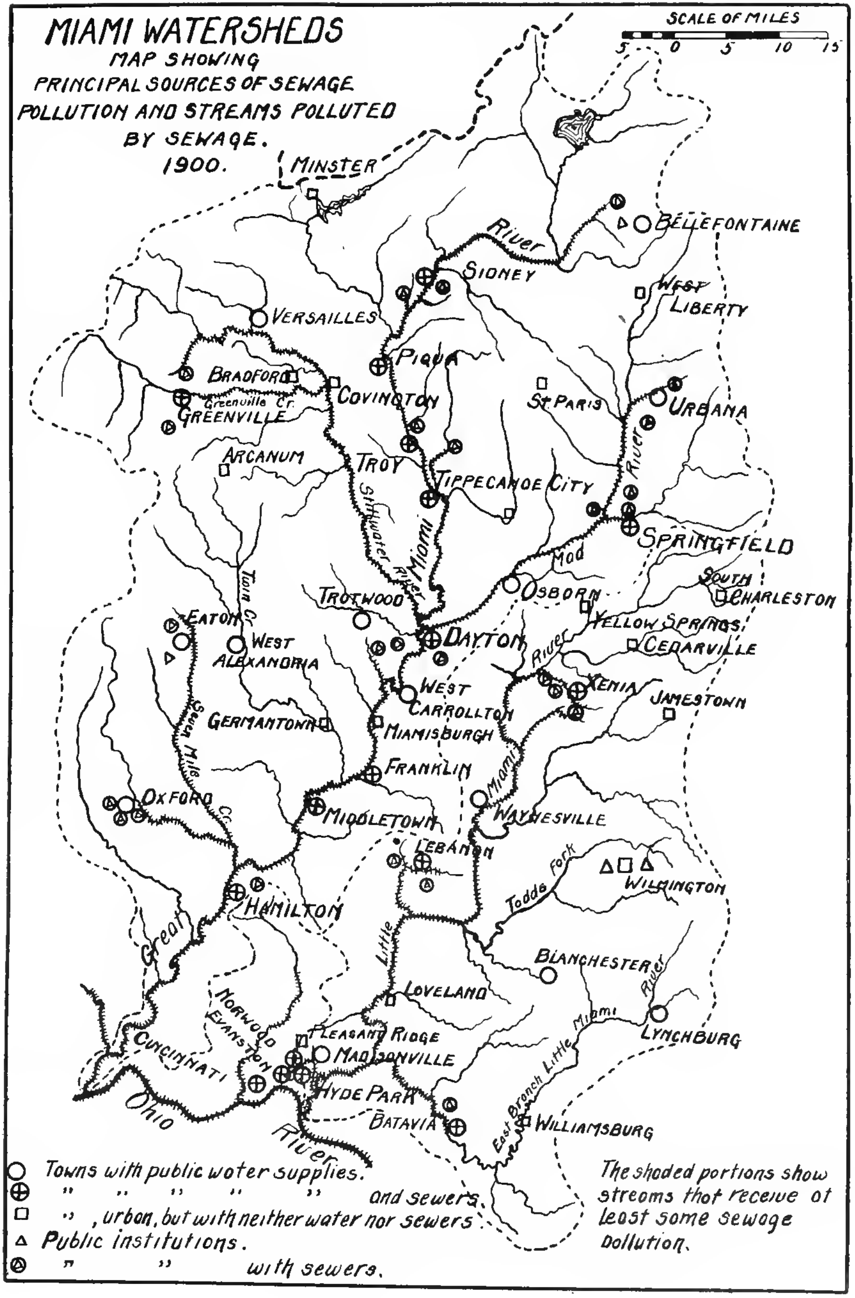
Greenville Creek above Greenville and Four Mile Creek above Oxford are free from this sewage; also Loramie Creek, but the lower village of Minster is located on this watershed. Mad River above Dugan Creek receives no sewage but drains the large village of West Liberty.

Twin Creek receives no sewage but receives the drainage from Germantown, West Alexandria and Lewisburg.

There are three cases in the Little Miami River, the main stream above Massick's Creek, Cæsar's Creek, and the East Branch above Batavia. These watersheds, however, include Yellow Springs and South Charleston, Jamestown and Williamsburg, and Lynchburg respectively.

With the clay land and objectionable farm drainage it would be difficult to find even a small stream which could furnish a potable water. In order to bring out the other phase of the question, that is the ability to dispose of sewage, the following table has been prepared, in which the relation of the urban population to the tributary watershed areas is shown:

PLATE 13



MIAMI WATERSHEDS
MAP SHOWING
PRINCIPAL SOURCES OF SEWAGE
POLLUTION AND STREAMS POLLUTED
BY SEWAGE.
1900.

TABLE VI — URBAN POPULATION IN RELATION TO WATERSHED AREAS.

Number.	Place.	Population.	Stream.	Area of watershed in square miles.	Area per 1000 of population.	Water and Sewerage.
1	Arcanum	1,225	Painter's Creek...	5	4.1	W.
2	Batavia	1,029	East Branch Little Miami River ..	456	346.1	W.
3	Bellefontaine	6,649	Stony creek and Buckinjahalas Cr.	*	....	W.
4	Blanchester	1,788	Second Creek.....	5	2.9	W.
5	Bradford	1,254	Greenville Creek 1 mile below......	193	153.9	
6	Portion of Cincinnati.	5,000	Little Miami River	1,706	34.1	W.
7	Cedarville	1,189	Massick's Creek...	62	51.6	
8	Cleves	1,328	Great Miami River	3,807	286.2	
9	Covington	1,791	Stillwater River ..	433	24.1	
10	Dayton	85,333	Great Miami River	2,536	29.7	W. & S.
11	Degraff	1,150	Great Miami River	390	28.7	
12	Eaton	3,155	Seven Mile Creek	21	6.6	W.
13	Portion of Evanston.	1,000	Duck Creek	1	1.0	W. & S.
14	Franklin	2,724	Great Miami River	2,680	98.5	W. & S.
15	Germantown	1,702	Twin Creek	301	17.7	
16	Greenville	5,501	Greenville Creek ..	118	21.4	W. & S.
17	Hamilton	23,914	Great Miami River	3,547	14.8	W. & S.
18	Portion of Hyde Park	1,000	Duck Creek	2	2.0	W. & S.
19	Jamestown	1,205	Caesar's Creek ...	*	....	
20	Lebanon	2,867	Turtle Creek	22	7.7	W. & S.
21	Loveland	1,260	Little Miami River	1,106	878	W. & S.
22	Lynchburg	907	East Branch Little Miami River	70	76.9	W.
23	Madisonville	3,140	Branch of Duck Cr	5	1.6	W.
24	Miamisburgh	3,941	Great Miami River	2,662	683	
25	Middletown	9,215	Great Miami River	3,075	334	W. & S.
26	Milford	1,149	Little Miami River	1,157	1000	
27	Minster	1,465	Loramie Creek ...	*	....	
28	Portion of Norwood.	3,240	Duck Creek	3	0.9	W. & S.
29	Osborn	948	Mad River	575	607	W.
30	Oxford	2,009	Four Mile Creek..	95	45.0	W.
31	Piqua	12,172	Great Miami River	863	70.9	W. & S.
32	St. Paris............	1,222	Black Snake Run.	*	....	
33	Sidney	5,688	Great Miami River	552	97.0	W. & S.
34	Springfield	38,253	Buck Creek	155	4.1	W. & S.
			Mad River 3 miles below	417	11.4	
35	South Charleston....	1,096	Little Miami River	7	6.4	
36	Tippecanoe City.....	1,703	Great Miami River	1,021	600	W. & S.
37	Trotwood	214	Wolf Creek	56	261	W.
38	Troy	5,881	Great Miami River	916	156	W. & S.
39	Urbana	6,808	Mad River	162	23.8	W.
40	Versailles	1,478	Swamp Creek	59	39.4	W.
41	Waynesville	723	Little Miami River	410	569	W.
42	West Alexandria.....	740	Twin Creek	155	209	W.
43	West Carrollton.....	987	Great Miami River	2,609	264.3	W.
44	West Liberty........	1,236	Mad River	32	25.8	
45	Williamsburg	1,002	East Branch Little Miami River ...	241	240	
46	Wilmington	3,613	Todd's Fork......	25	6.9	
47	Xenia	8,696	Shawnee Run 3 miles below.....	11	1.2	W. & S.
			Little Miami River	246	28.3	W. & S.
48	Yellow Springs......	1,371	Yellow Springs Cr.	4	2.9	

This table includes 4 towns with Public Water Supplies but not Urban.
*Drainage area too small to measure.

According to Hazen's estimates Ohio streams require a drainage area of from 15 to 40 square miles to dispose of, in an unobjectionable manner, by dilution, the sewage of 1,000 people. From the stream gaging that has been done in Ohio it is now evident that the low flows are much smaller than was expected, especially as most of the comparisons were made with the run-off of eastern streams. Instead of a minimum of 0.1 of a cubic foot, or a little less per second per square mile of drainage area, it is found that the average flow for a month, and in some cases two months, is less than 0.01 of a cubic foot per second per square mile.

This must modify seriously the estimates of the drainage area necessary to unobjectionably dispose of the sewage by dilution of 1,000 people. If the estimate of from 15 to 40 square miles for every 1,000 inhabitants is correct when based on a minimum flow of a little less than 0.1 cubic foot per square mile, it will be necessary to allow from 150 to 400 square miles for the minimum flow as actually found.

From an extended acquaintance with conditions over the state it would seem that the latter figures are very nearly correct. In studying this question it must be borne in mind that the 1,000 inhabitants refers to the population actually sending sewage to the streams.

In Dayton, with only a little more than one-sixth of the population using sewers, a drainage area of 30 square miles per 1,000 of the total population has not prevented a slight local nuisance.

The sewage of Evanston, Hyde Park, Lebanon, Norwood and Springfield causes a nuisance in every case, as would certainly be expected.

Greenville has 21 square miles per 1,000 of its population, and will only escape a nuisance until its system comes into general use. Xenia has gone at the matter in the proper way; they intend to put in the purification plant along with the sanitary sewers.

From the size and tributary drainage areas available it is very probable that purification works will be needed in the following towns as soon as a complete sewer system is put in and comes into general use: Arcanum, Bellefontaine, Blanchester, Cedarville, Covington, Eaton, Jamestown, Lynchburg, Madisonville, Minster, Oxford, Piqua, St. Paris, Sidney, South Charleston, Urbana, Versailles, West Liberty, Wilmington, and Yellow Springs.

V. ICE SUPPLIES.

The investigation of the ice supplies for a district as extensive as the one under discussion is of necessity limited to a brief outline of the principal sources unless more time and labor than could be given to it is available.

The most evident fact noticed in a study of this question is the growing importance of the artificial ice industry. The ever increasing pollution of the streams and ponds from which the natural ice was cut, together with the more general enlightenment of the public in reference to sanitary matters, has been gradually increasing the demands for the artificial product. In a thickly settled portion of the state, as found in the Miami valleys, it is impossible to find a stream of any size which does not suffer from more or less sewage pollution. The Miami and Erie canal, together with its basins and feeders, was at one time able to and did furnish an enormous amount of very fair ice, but now this waterway receives so much refuse that from but a very small portion of the system can a usable ice be cut.

It is possible, however with proper precautions, to get good ice from the back-water of dams in the small streams and from the small natural and artificial ponds. The ice may be high in organic matter, but if the drainage areas are kept free from pollution the ice is certainly usable. In a majority of the cases, however, it will be found that not the slightest precaution is taken and that ice is cut from ponds and streams the water of which cannot help but be most foul. Frequently, the artificial ponds are kept full of water during the ice season only and for the remainder of the year are merely swampy holes full of stagnant water. Too often also cattle and hogs have access to these ponds.

In the smaller villages, and some of the larger ones also, it seems to be a general practice for the local butcher to do his own slaughtering, and also have near his slaughter house a pond from which a supply of ice is cut for his own use. No attempt is made to protect this pond from pollution as it is claimed that the ice is for cooling purposes alone and its quality does not matter. It is true that a regular business is not made of selling this ice for domestic purposes, but it is a fact, however, that when an occasional piece of ice is required the local butcher is the one who furnishes it. In this way a considerable quantity of exceedingly filthy ice is marketed for domestic use.

Below are given a few notes on the sources of the ice supply for the cities and principal villages:

Of the larger cities nearly every one has one or more artificial ice plants, supplying both the local trade and shipping also to the neighboring towns.

Bellefontaine has a small artificial ice plant which supplies a portion of the local trade. Natural ice is shipped in from Lake Erie and cut locally from Silver Lake and a few small ponds.

Dayton is supplied with both artificial and natural ice. The Dayton Ice and Cold Storage Company has a plant which turns out about 90 tons daily during the season from May to October. The bulk of this is used in Dayton, but some is shipped to Hamilton, Miamisburg, Piqua, Troy, Xenia, and a number of smaller places. Three of the local breweries have each an artificial ice plant of from 30 to 35 tons capacity daily, a large portion of the product of which is used for general local consumptiton. The natural ice is cut by several companies from ponds fed from Mad, Stillwater and the Great Miami rivers.

In Eaton the Crystal Ice Company has an artificial ice plant of eight tons daily capacity. Nearly all of this is used locally; a small quantity is shipped to West Alexandria.

Nearly all the ice supply for Hamilton is made by a local brewery, which ships some out to surrounding villages. Some natural ice is cut from a basin fed by the hydraulic canal, which is in turn fed by the Great Miami River.

Lebanon is supplied with about five tons daily from a local artificial ice plant. A small amount of natural ice is cut from Turtle Creek and some is shipped in from Lake Erie.

Middletown has a local brewery equipped with an ice plant of 60 tons daily capacity. Natural ice is cut from ponds fed from the Miami and Erie canal.

In Springfield the Springfield Coal and Ice Company made, during the past year, 6,237 tons of artificial ice. The greater part of this was used locally, the remainder being shipped to Bellefontaine, Troy, etc. Natural ice is brought in from Lake Erie and from the Dayton ponds by five dealers.

The Urbana Ice Company supplies Urbana with ten tons daily, of artificial ice, practically all that is used in the city. Some natural ice is cut from local ponds, but its use is not extensive.

Piqua formerly had an artificial ice plant which supplied much of the ice used for domestic purposes both locally and for the neighboring towns, but this burnt during the last season and this city was compelled to use ice from the hydraulic and its basins, helped out with artificial ice shipped in from Dayton.

The cities and villages near Cincinnati, as Cleves, Evanston, Hyde Park, Madisonville, Norwood, Oakley, Pleasant Ridge, etc., are furnished with ice from the varied supply for this large city. Much of the ice used for domestic purposes is manufactured, though there is still an enormous quantity cut from the Miami and Erie canal and its basins and from ponds fed from this waterway.

Batavia, Blanchester, Bradford, Greenville, Oxford, St. Paris, Troy, West Alexandria, and Xenia are supplied partly with natural ice from local ponds and streams and partly with artificial ice from the plants at Cincinnati, Dayton, Eaton, Hamilton, Hillsboro and Urbana.

The remaining cities and villages of the Miami watershed are supplied almost entirely with natural ice from the various local sources. Practically all the ice used by the following villages is cut from local ponds fed from surface drainage: Ansonia, Arcanum, Bethel, Brookville, Camden, Jackson Center, Lewisburg, Mason, Milford, Mt. Washington, New Carlisle, New Vienna, South Charleston, Spring Valley, Versailles, Waynesfield, Wilmington, West Milton, and a host of smaller villages.

In the following list there are included the principal towns which depend almost entirely upon ice cut from the local creeks and rivers, usually from the back-water of some dam: Belle Center, Cedarville, DeGraff, Germantown, Jamestown, Loveland, Morrow, Osborn, Pleasant Hill, Quincy, Sidney, Waynesville, Williamsburg, West Carrollton, and Yellow Springs, also including, of course, the large number of small villages supplied in this way.

A few, including Covington, Franklin, Lynchburg, West Liberty, Tippecanoe City, etc., are supplied both from ponds and from flowing streams.

Lake View and its neighboring villages cut a considerable quantity of ice from the Lewistown reservoir.

Miamisburg is supplied with ice from ponds filled from the canal.

Near Le Sourdsville, in Butler county, there are a number of large ponds, supplied with water from the canal, from which formerly an enormous amount of ice was cut and shipped and from which there is still taken a considerable quantity.

VI. PUBLIC WATER SUPPLIES.

In the Miami watersheds there are 30 cities and villages which are supplied with water from 28 water-works. Cincinnati, Hyde Park, and Evanston, portions of which are within the watershed, are furnished with Ohio River water by Cincinnati works, which plant is outside of the watershed and will not be included in the discussion of the supplies themselves. Only a portion also of the population of Norwood is within the watershed, but this city is furnished with its own public supply from a source within the watershed.

There is within the watershed, in cities and villages supplied with water, a total population of 242,762, of which 238,243 are classed as urban. There are six villages, Osborn, Trotwood, West Alexandria, West Carrollton, Lynchburg, and Waynesville, with a total population of 4,519, which have water-works, but are not classed as urban as each has a population of less than 1,000. Of these Trotwood, with a population of 214, is the smallest; in fact this village is the smallest in the state to be so provided. The first four named villages are in the Great Miami watershed and the remaining two belong to the Little Miami.

Of the urban towns not supplied with water there are ten, with a total population of 16,314 in the Great Miami; and eight, with a total population of 11,885 in the Little Miami watershed, making a total of eighteen, with a population of 28,199. Two of these eighteen, Miamisburgh and Wilmington, have populations of 3,941 and 3,613 respectively, and are sadly in need of a public water supply. It is impossible, with conditions as they exist in Ohio, for villages of this size to obtain a potable water from the average private well. As a general rule it is very difficult to obtain a satisfactory water from the private wells of any of the urban towns, and they would all be benefited by the installation of a good public water-works.

The percentage of urban towns without water supplies, in these watersheds, is larger than for any of the other districts which have been investigated. In the Great Miami there is a total of 26 towns classed as urban, only 16 of which have water-works, while the Little Miami has only eight provided with water out of a total of 16, or in both the watersheds there are only 24 water supplies in 42 towns. No doubt much of this slowness to take up public improvements is due to the fact that a large number of the citizens of these villages are retired farmers, who have come in to live at ease on very moderate incomes. It is a class who have lived nearly their whole lives without the conveniences of a modern community and no desire is felt for them, especially as their installation adds materially to the tax rate at first.

The commercial and industrial elements are nearly always for the improvement of the village and where these predominate there is usually no trouble in securing votes. It usually requires a severe fire or an especially fatal epidemic of some water-borne disease before many of these communities see the need of a public water supply.

As stated in the last annual report, and repeated here in the hope of dispelling the doubts of some hesitating community; there has been invented no method of carrying off the wastes of the human economy which is as sanitary, unobjectionable and cheap as the water-carrying system, and no public improvement will do so much for the prosperity of a village and for the health of its people as the introduction of a good potable water supply in connection with a complete sanitary system of sewers.

CLASSIFICATION.

For convenience in studying the public water supplies they have been divided with reference to source into the usual classes: Surface and Ground. The "Ground" division is further subdivided into Subsurface and Deep-seated waters, according to the character of the same, as explained by the terms. As has been stated this division is not always easy to make, but it is the intention to keep in the first class all waters the purity of which is easily influenced by surface pollution, and to place in the latter class those supplies which are drawn from such depths or through such strata that the surface conditions have but little if any influence.

According to the above divisions the following table has been prepared.

TABLE VII — CLASSIFICATION OF PUBLIC WATER SUPPLIES.

Classes.		Towns.	Population.	Totals
(A) Surface......		1—Batavia	1,029	
		2—Piqua	12,172	
		Total		13,201
		Average		6,600
(B) Ground......	Subsurface.	1—Dayton	85,333	
		2—Eaton	3,155	
		3—Franklin	2,724	
		4—Greenville	5,501	
		5—Hamilton	23,914	
		6—Lynchburg	907	
		7—Middletown	9,215	
		8—Osborn	948	
		9—Oxford	2,009	
		10—Tippecanoe City..	1,703	
		11—Trotwood	214	
		12—Troy	5,881	
		13—Urbana	6,808	
		14—Versailles	1,478	
		15—Waynesville	723	
		16—West Carrollton..	987	
		Total		177,500
		Average		10,719
	Deepseated	1—Bellefontaine	6,649	
		2—Lebanon	2,867	
		3—Madisonville	3,140	
		4—Norwood	6,480	
		5—Sidney	5,688	
		6—West Alexandria.	740	
		Total		25,564
		Average		4,264
		Total	....	177,064
		Average	....	8,048
(C) Surface and Ground	Surface and Subsurface	1—Blanchester	1,788	
		2—Springfield	38,253	
		3—Xenia	8,696	
		Total	....	48,737
		Average	....	16,246
		Grand total..	....	239,002
		General average......	....	8,852

This table brings out, even better than in any of the other watersheds studied, that there are but few streams left in the state that can furnish a potable water supply.

In the Miami watersheds there are but two towns supplied wholly with surface water. One of these supplies, Batavia, is filtered before using, and the other, Piqua, is not fit for domestic use and is not used for such purpose by any of the citizens of that city, and if the present financial troubles of Piqua are straightened out, the city will soon be supplying its citizens with a sub-surface water which has already been developed, thus leaving only one supply entirely from surface sources.

In the Surface and Ground division there are three towns supplied with surface and sub-surface water. Blanchester obtains such a large percentage of its supply from an impounding reservoir that its ground water is lost sight of and the whole is rendered unfit for domestic use from the poor quality of the surface water.

Springfield does not actually belong in this class and would not now be in it but for two dry years which cut down its excellent ground supply to such an extent as to compel it to go to Buck Creek in order to tide over several short days and to secure a reserve for fire protection. Ordinary years, or with a further development of the ground supply, this city would belong to the "sub-surface" class.

The original supply of Xenia was obtained by impounding the runoff from several springs together with some surface water. This has since been supplemented by a ground water which is as yet used only during the dry season when the reservoir runs low.

Sidney's first supply was entirely from surface sources, but these have long been abandoned for a deep-seated water.

In the above list of 27 supplies, only one, that of Batavia, appears to be permanently from a surface source and that only because a filtration plant has been installed. Three, Piqua, Sidney and Xenia, are now, or were originally, supplied practically with surface water and have or intend to replace it with ground water, or are in a transitory state. Two, Blanchester and Springfield, have been compelled to supplement ground water with surface water from lack of a sufficient amount of the former. Of these 27 supplies, 22 are entirely from ground sources.

The total population supplied either wholly or in part with surface water, is 61,938, of which 50,425 are furnished with it as a temporary expedient only, or the ground supply is under way. The remaining 11,513, or 5 percent of the grand total, are for the present to be supplied with surface water.

The 22 ground supplies are for a population of 177,064, or 74 percent of the total population in the towns with public water supplies. Of these ground water supplies 16 of the 22, with a total population of 171,500, are of sub-surface origin and the remaining six, with a population of 25,564, are of deep-seated origin.

Dayton, population 85,333, is one of the largest cities in the United States which is supplied entirely by ground water. With the exception of Lynchburg and possibly Versailles, all the ground water supplies may be considered as satisfactory so far as potability is concerned. The sub-surface supply for Urbana is taken from a point in a direct line with the under drainage from the city, and it may in time suffer some deterioration though at present it is entirely potable.

A few of the ground waters are slightly objectionable from the presence of iron, and many are too hard for an ideal water, but neither of these objections is fatal to their use for a public supply, especially in this state where it is the rule to collect rain water in cisterns for the laundry, bath, etc.

DETAILED DESCRIPTION OF PLANTS.

Following are the detailed descriptions of the public water supplies of the two watersheds, except for the towns of Eaton, Greenville, Piqua, Sidney, Springfield and Urbana. The water-works for the first five of these are fully described in the annual report of the State Board of Health for 1898, and that for Urbana in a special report in the annual report for 1900. However, a brief description will be given here of these supplies, with special reference to changes in supply and increase of mains, services, etc.

Batavia. Population 1,029. The public water supply was put in by the village in 1900, at a cost of $31,000, including the electric light plant. The supply is obtained from the East Branch of the Little Miami River at a point just above the village and above all local pollution. As seen from the description of the watershed the East Branch drains a hilly farming country, and receives no especial pollution until Lynchburg, 42 miles above, is reached; at which place a large distillery winters some 1,000 head of cattle, the filth from which enters the stream direct. Before this source was approved filtration was required by the Board. The village presented plans for a rather crude system of slow sand filtration which were here hardly satisfactory and finally plans for mechanical filtration by the We-fu-go process, this latter being approved. The water is pumped from the river by a low service pump to two sedimentation tanks situated on the side hill back of the filter house and pumping station. From these tanks the water flows by gravity onto the filter, through it to a clear water well, from which it is pumped to a supply reservoir situated on the high ground north of the village.

The filtration process involves the use of a coagulant, sulphate of aluminum, in this case, which is admitted to the water as the latter passes to the sedimentation basins. The coagulant solution is pumped from the coagulant tanks by a small piston pump actuated by the low service pumps so that a constant ratio is maintained between the amount of solution and the amount of water pumped. The actual amount of coagulant used must be varied by changing the strength of the solution; it is usualy one grain per gallon. At times of high turbidity in the stream it will be necessary to increase this amount in order to get perfect clarification.

The sedimentation tanks are two in number and consist of open wooden tubs, each 20 feet in diameter and 13½ feet high, with an effective height of 10 feet, giving a capacity of 23,660 gallons each or 47,320 gallons for both. These tanks are exposed to the weather, with no protection whatever. As the water enters the tanks it falls over the sides of a pan secured to the discharge pipe of the pump and receives more or less aeration, The tanks are used alternately, an automatic device admitting the water to first one and then the other, thus securing a longer period of quiet sedimentation. The outlet from these tanks is supplied with a skimmer float so as at all times to secure the clearest water for the filters. The tanks are supplied with suitable pipes for flushing out the collected sediment.

The filter consists of an 8-foot cypress tank, 8 feet deep, fitted with a double bottom, the upper one of which is fitted with brass strainers supplied with phosphor bronze screens. The openings in the screens are approximately ¾ by 1/100 inches. In the bottom of the strainer is placed a brass ball so arranged as to throttle the downward flow but to allow a free upward flow of the wash water. On the screens rest a two foot nine inch bed of sand, composed of crushed quartz. The compartment between the bottoms is for the collection of the clear water and to this is connected the discharge pipe of the filter which is fitted with a regulator so that the rate of filtration is kept uniform, irrespective of the condition of the bed. The inlet pipe is controlled by means of a float, so that a uniform level is maintained on the bed. A positive head of 4 feet is maintained on the filter and a suction head of seven feet, making a total of eleven feet.

The filter is washed by reversing the flow through the sand and at the same time stirring it with a revolving mechanical agitator. The wash water is carried off by an annular trough fastened inside of the filter tank.

The total filtering area is 50 square feet, or 0.0012 of an acre, giving, at the standard capacity of 120,000,000 gallons per day a rate of filtration of 100,000,000 gallons per acre per day.

The clear well is 42 feet in diameter and 16 feet deep, with a capacity of 165,000 gallons.

The low service pump is a horizontal duplex McGowan of 500,000 gallons capacity. The water is pumped from the clear well to the reservoir by two horizontal duplex McGowan pumps of 750,000 gallons capacity each. The pressure at the station is 95 pounds, and the average on the mains is somewhat less than this. The reservoir is 30 feet in diameter and 17 feet deep, with a capacity of 84,000 gallons. Both this reservoir and the clear well have brick walls laid in cement and concrete bottoms and neither is covered.

There are 3.5 miles of mains in, to which some 90 percent of the people have access. There are 26 services in all, of which all are in use and none metered. As the plant has been running for so short a time no estimate can be made on the average daily consumption. The water after filtration is clear and seems to be of excellent quality and should displace the private wells, many of which are badly contaminated.

Bellefontaine. Population 6,649. The public water supply was put in by the village in 1882, and has cost to date $140,000. The water is obtained from four 8-inch wells located just south of the village in the valley of a small stream. The wells are 160 feet deep and go through 80 feet of gravel and clay and 80 feet into limestone. The supply has always been sufficient, but it is intended to put down a number of shallow wells in the gravel for an additional supply. There is no local pollution of the grounds and it is a question, even if there were, whether it would affect the deep wells.

The water is pumped direct from the wells to a reservoir by two horizontal compound duplex Gordon pumps of 750,000 gallons capacity each. A new vertical compound duplex Snow pump of 2,500,000 gallons capacity is to be installed soon, for reserve in case of accident to the present pumps. The reservoir is located on high ground to the east of the village and gives a pressure of 80 pounds at the station and an average of 60 pounds over town. It is an open basin 206 by 106 by 20, holding 2,000,000 gallons, with sloping sides built of brick laid in cement. The whole is surrounded by a high barbed-wire fence for protection from contamination.

There are 17.0 miles of mains in, to which some 95 percent of the people have access. There are 956 services in, of which 900 are in use and only 18 metered. It is intended to increase the number of meters very soon so as to cut down waste, as the consumption is very large for a village of this size. The average daily consumption is 642,000 gallons, which is 714 gallons per service, 143 per consumer, and 94 per capita of the total population.

Blanchester. Population 1,788. The public water supply was put in by the village in 1896, and has cost to date $30,000. An electric light plant costing $10,000 is in the same building. The supply was to be obtained from 3 wells 6 feet in diameter and 50 feet deep, but they soon failed and the village was without water, as there were no funds available for a new supply. In 1899 a private company was formed among the citizens of the village for the purpose of securing a supply of water for fire protection at least. A franchise was obtained from the village under which they were to supply the water, the village to pump the same, and the company to have the privilege of collecting the private water rents.

As ground water was not available and there were no streams near of sufficient size to secure a supply, a reservoir was excavated in the valley of a small run, having a drainage area of 1,400 acres, and a surface supply impounded. The reservoir has an area of about 3 acres and an average depth of 6 feet, giving a capacity when full of some 5,000,000 gallons. The reservoir was formed by excavating the upper end and by an embankment around the lower portion. The sides and bottom are not paved or protected in any way, and the water is very muddy for a long period after each rain. In the spring of 1900 a heavy rain caused a flood, too large for the waste-way, and the reservoir banks were overflowed and a portion broken out. The waste-way is 10 feet long and can flow 5 feet deep before the reservoir banks will overflow. This would require a rainfall of $\frac{1}{4}$ inch per hour over the entire watershed, of such duration as would allow the water from the most remote section to reach the river; it would also have to be on a soil, impervious from continual rain or freezing. The reservoir with connections, etc., cost $6,000.

The water from the reservoir flows by gravity through an 8-inch pipe to the old wells in which the suction of the pumps is placed. The water in the wells will rise to within 7 feet of the surface when pumping is suspended for some time and the reservoir line will not flow until the wells have been lowered to 12 feet so that a small amount of well water is supplied, but it is a very small proportion of the total consumption and can hardly be considered.

The water is pumped direct from the suction wells to an elevated tank by two horizontal compound duplex McGowan pumps of 750,000 gallons capacity each. The pressure is 50 pounds at the station and averages 45 pounds on the mains.

There are 11 miles of mains in, to which 90 percent of the people have access. There are 70 services in, all of which are in use and 10 metered. The average daily consumption is about 15,000 gallons, which is 214 gallons per service, 43 gallons per consumer, and 9 gallons per capita of the village.

The water is not used for domestic purposes at all and is not fit for such use without filtration.

Dayton. Population 85,333. The public water supply was put in by the city in 1869 and cost to January 1, 1900, $1,363,282, for construction alone. The total expenditure of the water-works department for the thirty years was $2,108,721, of which $745,429 was for maintenance. The total income for the same period was $1,248,638, showing the net cost of the plant to be $860,083, a figure much below the present value of the works. The construction account for 1900 will be heavy as a new suction line is being put down, also new wells, and a large pump is to be put in requiring extensive changes in pumping station, etc.

The first supply was from Mad River direct, but this was abandoned in 1887, when the first of the present extensive system of wells were put down. There are now eighty-seven 8-inch wells, driven 30 to 60 feet in the bed of Mad River in the upper portion of the city. During the past year 24 of the old wells were replaced and 20 additional new ones put in, bringing the total to the figure named above.

The bed of Mad River consists of a very porous gravel which carries a large amount of water, the sub-surface flow of the stream. The normal level of the water in the wells coincides with the river level except in very low stages when it rises above the surface water level. On a test one well gave 400 gallons per minute with the level lowered only 5 feet. At this same test a well 50 feet away was lowered only 4 inches. The wells extend up and down the river 2,000 feet each way from the pumping station and until this year were reached by a 30-inch suction line going down the river and by a 20-inch and 30-inch going up. A new 5 foot suction line is being put in up the river to replace the small lines and also, in time, to extend above them as new wells are added.

While the site of the wells is above all sewage pollution it does not escape all manufacturing refuse, especially that from a strawboard works. Except in times of extreme low water it is doubtful whether any of this refuse would influence the sub-surface water, but at such dry times some of it would soak into the gravel bed, where, if the filtration were not perfect it would pollute the water of the wells. This is a phase of the question which must be watched in the future. It may be advisable at no distant time to put in a sewer or conduit that would care for all the objectionable drainage to the river above the wells.

The water is pumped direct to the mains by a 4,000,000 quadruplex Holly pump installed in 1873, a 10,000,000 gallon horizontal, compound, duplex Holly pump erected in 1889, and a 15,000,000, gallon pump of the same pattern, installed in 1895. A new 10,000,000 gallon vertical, triple expansion Holly is now being put in.

The domestic pressure averages 60 pounds. There are 117.9 miles of mains in, giving some 90 percent of the total population access to the water. There are 12,018 services in, of which 9,500 are in use and 563 of these metered, about 60 are for hydraulic elevators.

The average daily consumption is 5,098,000 gallons, which is 537 gallons per service, 98 per consumer, and 60 per capita of the total population.

The water is of excellent quality and is in general use to the gradual exclusion of private wells.

Eaton. Population 3,155. A detailed description of the public water supply for this village was given in the report of the State Board of Health for 1898, and there has been no change in the source since that time. There are now 417 services in, of which 407 are in use and 168 of these are metered. The average daily consumption is 58,800 gallons, which is 144 gallons per service, 29 per consumer, and 19 per capita of the village. A comparison with the report for 1898 will show that the estimate of the consumption was much too high; the present figure is from the pumping records for the year. The low consumption is due to the absence of manufacturing plants and also to the total lack of sewers. There are about 30 water-closets supplied by the system, the waste water going to cesspools.

Franklin. Population 2,724. The public water supply for this place was put in by the village in 1887, and has cost to date $57,000. The supply is obtained from six 6-inch wells driven 65 feet into a clay, sand, and gravel bed bordering the Miami and Erie canal in the lower part of the village. The water stands, normally, 22 feet below the surface and is lowered but little by the ordinary consumption. There is direct connection with the canal for use in cases of emergency.

The water is pumped direct from the wells to the mains by two horizontal, compound, duplex Holly pumps of 750,000 gallons capacity each. The pumps are set 18 feet below the surface so as to keep the water well within the suction limit. The station pressure carried is 60 pounds and the average on the mains is 55 pounds.

There are 8.0 miles of mains in, giving some 90 percent of the people access to the water. There are 410 services in, of which 340 are in use and 24 of these are metered. The average daily consumption is estimated at 300,000 gallons, which is 882 gallons per service, 172 per consumer, and 110 per capita of the total population. The large consumption is due to the extensive use of the water by the various paper mills. Some of it is also due to the large amount of leakage claimed to be caused by the deterioration of the pipes from electrolysis.

Greenville. Population 5,501. Since the supply for this village was reported on, in 1898, there have been added six new 8-inch wells, averaging in depth from 46 to 54 feet. These go through various layers of clay and gravel down nearly to bed-rock. These walls are in the same location as the old ones and were put down merely as a safeguard against the failure of the first set. This, together with the running of a large number of services to the curb on account of street paving, has run the total cost up to $101,000.

There are now 717 services in, of which 450 are in use and 257 of these metered. The average daily consumption is 218,000 gallons, which is 484 per service, 97 per consumer, and 40 per capita of the whole population

Hamilton. Population 23,919. The public water supply was put in by the city in 1884 and has cost to date $365,000. The first supply was from a large well or basin situated in the low land north of the city, and lying between the Great Miami River and an abandoned channel of the same stream. The basin was 500 feet long, 100 feet wide, and 15 feet deep, dug into a large bed of gravel.

The supply from this source was unsatisfactory and in 1889 a number of deep wells were driven in the basin and these, with additions, have furnished the supply since that time. Now there are nineteen 6-inch and three 8-inch wells, driven from 75 to 135 feet into the bed of gravel.

The water flows from the wells at the river level and is conducted about 1,000 feet to a receiving basin set 13 feet below mean low water in the river. The receiving well is a closed brick chamber 28 by 13 by 33 feet deep, with a capacity of 90,000 gallons.

The water is pumped from this basin to a supply reservoir by a vertical, compound, duplex, Gordon-Maxwell pump of 3,000,000 gallons capacity. The average domestic pressure is 90 pounds. The reservoir is situated on the high ground west of the Great Miami River, and is reached by two mains, a 20-inch main laid in the bed of the river, and a 10-inch main crossing on a bridge. It is an open basin with sides paved with brick in cement, and is 200 by 270 by 24 feet deep, with a capacity of 7,000,000 gallons. As first constructed the reservoir was not cemented and there was frequent trouble with growths of various kinds. Since the sides were cemented, however, no trouble has been reported.

There are 40 miles of mains in, giving some 95 percent of the population access to the water. The mains even extend outside of the corporation in order to supply several manufacturing plants. There are 3,295 services in use and 827 of these metered. The average daily consumption is 1,818,000 gallons, which is 569 gallons per service, 103 per consumer, and 76 per capita of the total population. It will be noted here that the pumping capacity is less than twice the average daily consumption, a rather perilous condition for a pumping plant to be in notwithstanding the very fair reservoir capacity.

Lebanon. Population 2,867. The public water supply was put in by the village in 1896, and has cost to date $52,000. A light plant has recently been installed in the same building, at a cost of $20,000 completed. The supply is obtained from six 6-inch wells driven from 96 to 104 feet through alternating strata of clay, sand, and gravel. The wells are located a short distance west of the village in the low ground bordering a small tributary to Turtle Creek.

The water from the wells is siphoned to a receiving well from which it is pumped to a standpipe by two horizontal, compound, duplex, Stillwell-Bierce and Smith-Vaile pumps of 750,000 gallons capacity each. The supply from the wells is such that the water in the receiving well can be lowered only 10 feet by the present pumping capacity.

The receiving well consists of a brick cistern covered with a tin roof and is 40 feet in diameter and 25 feet deep, with a capacity of 235,000 gallons. The standpipe is 80 feet high and 25 feet in diameter, with a capacity of 300,000 gallons. The average pressure on the mains is 70 pounds.

There are 10 miles of mains in, to which at least 95 percent of the people have access. There are 442 services in, of which 430 are in use and 12 of these metered. Two of the meters are on the lines to the County Infirmary and Children's Home, respectively.

The average daily consumption is 105,000 gallons, or 244 gallons per service, 49 per consumer, and 37 per capita of the total population. The water seems to be of excellent quality and is in general use for domestic purposes.

Lynchburg. Population 907. The public water supply was put in by the village in 1896, and has cost to date, together with an electric light plant, $18,000. The first supply was obtained from a dug well 16 feet in diameter and 20 feet deep, which enters a bed of gravel just above the rock. This well soon failed to supply enough water and a 4-inch suction line was run to a large basin from which a distillery obtains its water supply. This basin consists of a trench 120 feet long by 15 feet wide, with an 18-foot well at each end, all excavated 15 feet deep in a bed of sand and gravel. The sides of this basin are planked up and the whole is covered with a flat plank roof at the ground level. It occupies a low swale and is easily accessible to surface drainage, much of which is very objectionable. The well is situated nearly in the center of the village and its water is more or less polluted by objectionable surface drainage. In 1900 the 4-inch suction line to the distillery basin was replaced by a 5-inch line.

As the distillery opens for the season in November and will use practically all of the water available from the basin, the village was compelled to seek a new supply. Application was made to the State Board of Health for the approval of three springs, only one of which could be considered, namely, the "Sulphur" spring, located one and one-fourth miles northeast of the village in the low land near a small run. With suitable care this spring ought to be able to provide at least 20,000 gallons of potable water per day, and its use was approved by the Board.

It is at such a height that the water could be conducted by gravity to a pump well at the present station.

The water is pumped from the well and basin to an elevated tank by a horizontal, duplex, Laidlaw-Dunn-Gordon pump of 250,000 gallons capacity. The tank is 16 feet in diameter, 20 feet high, with a capacity of 30,000 gallons, and is placed on a trestle 89 feet high. The average pressure on the mains is 40 pounds.

There are 3.5 miles of mains in use, to which 80 percent of the people have access. There are 104 services in, of which 94 are in use and none metered. The average daily consumption is estimated at 25,000 gallons, which is 266 gallons per service, 53 gallons per consumer, and 28 per capita of the total population. The water is not in general use for domestic purposes.

Madisonville. Population 3,140. The public water supply was put in by the village in 1892 and has cost to date, together with an electric light plant, $66,500. The water-works cost alone about $35,000. The supply is from one 6-inch well and two 8-inch wells, each 150 feet deep and drilled through various strata of clay, quicksand and gravel down to the rock. The wells are located just west of the village in the low valley of a branch of Duck Creek. The normal level of the water is 21 feet from the surface.

At first the wells were pumped by direct suction, but this method failed to supply enough water and in 1895 three deep well pumps were put in. The wells are only 12 feet apart and within the walls of the pumping station, conditions favorable to the installation of deep well pumps. All the pumps are the double acting Laidlaw-Dunn-Gordon type, two having a capacity of 500,000 gallons each, and the third 350,000 gallons. The pump cylinders are placed 120 feet from the surface.

The water is pumped by the deep well pumps to a receiving tank and from this direct to the mains by two horizontal, compound, duplex, Laidlaw-Dunn-Gordon pumps of 1,000,000 gallons capacity each. The receiving chamber consists of a covered steel tank 20 feet in diameter and 15 feet high, with a capacity of 55,000 gallons. The pressure at the station is 80 pounds and the average on the mains is 50 pounds.

There are nine miles of mains in, giving some 90 percent of the people access to the water. There are 188 services in, of which 96 are constantly in use and 83 in use during sprinkling season only. The average daily consumption is estimated to be 110,000 gallons, or 800 per service, using the average number in use, 160 gallons per consumer, and 35 per capita of the total population. The water seems to be of excellent quality and is in general use for domestic purposes, where it is available.

Middletown. Population 9,215. The public water supply was put in by the city in 1874, and has cost to date $110,000. The supply is obtained from a large well 20 feet in diameter and 35 feet deep, dug in a gravel bed in the upper part of the city and near the Great Miami River. The normal level of the water is 16 feet below the surface and it is lowered about 11 feet by ordinary consumption in the dry season. The supply has always been sufficient except in 1893, when it failed during a period of exceptionally dry weather.

The water is pumped direct from the well to the mains by a quadruplex Holly power pump, installed in 1874. The pump has a capacity of 1,250,000 gallons per day and is operated by a 56-inch American turbine operating under a 17-foot head of water, secured from the Middletown hydraulic.

In 1885 two horizontal, compound, duplex, Smith-Vaile steam pumps of 1,500,000 gallons capacity each were installed. These are for reserve and for use in case of fires, steam being kept at low pressure in one boiler all the time. In cases of emergency the water from the hydraulic can be admitted to the well.

Enough water power to supply the domestic pressure is obtained from the hydraulic at an annual rental of $260, certainly a very economical method of pumping. A pressure of 45 pounds is maintained at the station and the average on the mains is 40 pounds.

There are 18.0 miles of mains in, to which some 75 percent of the people have access. There are 1,095 services in, of which 995 are in use and 62 of these are metered. The average daily consumption is 900,000 gallons, or 904 gallons per service, 180 per consumer, and 98 per capita of the total population. The large consumption is due to some extent to the general use of the water for industrial purposes; also to an extensive waste, induced by the cheap water and fostered by the small number of meters.

The water from the well seems to be of excellent quality and the authorities are trying to prevent its pollution by regulating the construction of vaults in the upper part of the city in the general vicinity of the well.

Norwood. Population 6,480. This village is on the divide between Duck Creek and Mill Creek, and only about half of its population is tributary to the former, or the Little Miami watershed.

The public water supply was put in by the village in 1894, and has cost to date $154,138. A light plant was installed in the same building, costing, completed, $34,501. The original supply was from six drilled wells, 235 feet deep and 6 and 8 inches in diameter. These wells began to fail and two 10-inch wells were drilled 260 feet deep through clay, gravel, and sand and into the limestone rock a few feet, which have furnished the whole supply since September 1st, 1900. The normal level of the water is 110 feet from the surface and it is lowered but little by pumping. The wells are located in the eastern part of the village, but the water will not be greatly liable to pollution on account of the depth at which it is found, 240 feet, and the general introduction of sewers which has prevented the construction of vaults. A third well is being put down so as to have an ample supply.

The water is pumped to a receiving basin by air-lifts and from there to a standpipe by two horizontal, compound, duplex, Laidlaw-Dunn-Gordon pumps of 750,000 gallon capacity each. Compressed air is supplied by a Rand Drill Company's compressor and by a new Ingersoll-Sergeant compressor, the former being held in reserve. A 3-inch air line is carried down 240 feet in the well and the water is forced up between this and the casing.

The receiving basin is an open oval-shaped cistern, 15 by 20 by 8 feet deep, with a capacity of 14,000 gallons. The standpipe is 60 feet high, 40 feet in diameter, with a capacity of 537,000 gallons, and is placed on a hill of such height that the station pressure is 112 pounds, standpipe full, and the pressure on the mains varies from 104 to 142 pounds.

There are 35 miles of mains in, giving some 95 per cent of the people access to the water. There are 974 services in, of which 874 are in use, and 140 of these metered. Owing to the changes in the plant the consumption could not even be estimated.

Osborn. Population 948. The public water supply was put in by the village in 1895, and has cost to date, including the electric light plant, $30,000. The supply is obtained from four 6-inch wells in the northern part of the village. The wells are driven 50 feet through a thin stratum of clay and into a large bed of gravel. The normal level of the water is from 15 to 18 feet below the surface and it is lowered but little by pumping.

The water is pumped direct from the wells to a stand-pipe by a horizontal, compound, duplex, Laidlaw-Dunn-Gordon pump of 500,000 gallons capacity. The standpipe is 10 feet in diameter, 125 feet high, and has a capacity of 70,000 gallons. The station pressure is 60 pounds and the average on the mains is 50.

There are 3.0 miles of mains in, to which some 80 percent of the people have access. There are 100 services in, of which 97 are in use and none metered. The average daily consumption could not be obtained.

The water seems to be of good quality but it is not in general use as yet for domestic purposes.

Oxford. Population 2,009. The public water supply was put in by the village in 1896, and has cost about $45,000. The supply is obtained from a large well dug in the sand and gravel bed near Four Mile Creek, some distance northeast of the village. The well is 20 feet in diameter, 35 feet deep, and is walled up with brick laid in cement and arched over so as to prevent flooding during high water, which overflows the well site. The top of the well is provided with a ventilator above high water. The normal level of the water is 9 feet from the surface but it is frequently lowered to 24 feet by pumping.

The water is pumped direct from the well to the mains by two horizontal, compound, duplex, Smith-Vaile and Stillwell-Bierce pumps of 750,000 gallons capacity each. The pressure on the mains varies from 45 to 65 pounds.

There are 7.0 miles of mains in, which give some 95 percent of the people access to the water. There are 234 services in, of which 211 are in use and 9 of these metered. The daily average consumption is 30,000 gallons, which is 142 gallons per service, and 15 per capita of the village. The total number of consumers is hard to estimate owing to the fact that 3 quite large institutions are supplied, but the consumption per consumer cannot be far from 25 gallons.

Piqua. Population 12,172. As yet there has been no change in the water supply for this city since the 1898 Report of the State Board of Health, though the water-works trustees have developed a ground supply which secured the approval of the Board, but owing to local jealousies and difficulties this water has not been substituted for that of the "Hydraulic."

The trustees put down twenty-three 4-inch wells in the bed of the Great Miami River north of the city and in the valley of the Ross Creek adjoining. These wells were from 48 to 134 feet deep, driven through various strata of soil, clay, gravel and sand. A good flow of water was found in 14 of the wells and these were reserved for the public supply. While there are certain local conditions which might interfere with the continued purity of the water, yet they are so unimportant and so easily overcome that the well supply should be installed at once as it is so vastly superior to the water from the hydraulic.

The secretary of the water works, Mr. W. B. Mitchell, has given in his last report, figures on the original cost of the plant and hydraulic and the cost of additions:

Original cost of hydraulic	$268,911 64
Original cost of water-works	56,896 84
Total	$325,808 48
Additional cost of water-works	63,896 84
Total cost of plant complete to May 1, 1900	$389,705 32

In addition to the above the new wells cost $2,861.71, all of which came from the revenue of the plant. The total cost of operating the plant, maintenance of hydraulic, etc., exclusive of interest was $5,144.32 for the past year.

There are now 24.5 miles of mains in, giving some 90 percent of the people access to the water. There are 1,400 services in, of which 1,320 are in use and none metered. The average daily consumption is estimated at 1,500,000 gallons which is 1,136 gallons per service, 227 per consumer, and 123 per capita of the total population. This large consumption is due to the general industrial use of the water and to the excessive wastage, brought on by no meters and a poor quality of water.

Sidney. Population 5,688. There has been no change in the supply for this city since our report of 1898.

At this time there are 14.5 miles of mains in, giving 95 percent access to the water. There are 800 services in, of which 700 are in use and 24 of these metered. The average daily consumption is 639,000 gallons, which is 913 gallons per service, 183 gallons per consumer, and 112 gallons per capita of the city's population. The consumption will soon increase as it is intended to put in a complete sanitary sewer system, thus increasing the number of houses supplied with closets, baths, etc.

Springfield. Population 38,253. Since our report of 1898 this city has had considerable trouble from a partial failure of the supply of water from the large well and gallery. On account of the extremely dry weather of 1899 it was necessary to help out with water from the wells and galleries of the old station, the former source of the total supply. The water from this source was pumped, by the old engine left at the station, to the reservoir near the new station and allowed to flow from there to the pump well. Even this increase in the supply was not sufficient for all purposes and Springfield was left in very bad shape for fire protection.

To overcome this danger the trustees, in the early part of the summer of 1900, tapped the old 20-inch main leading from the old station to the reservoir at Buck Creek and put in a 12-inch pipe, so that the creek water can flow direct to the reservoir. The intention was to keep the reservoir full in this way and to allow the water to seep through into the gallery and pump well and only use the water direct in case of fire. This reservoir is 250 by 500 by 15 feet deep and as it is excavated in a rather porous gravel bed, nominally its water level is equal to and varies with the height of the ground water.

It was the intention to reinforce the ground water with seepage from this reservoir supplied from the creek, and such use would not be objectionable, but as the reservoir puddled very soon with turbid creek water this seepage action was necessarily slow and it was necessary on a few occasions to run the creek water direct to the pump well, by the way of the reservoir and a 36-inch pipe from the latter to the pump well.

There are local difficulties, as well as sanitary, regarding the use of Buck Creek water, in the nature of suits for diverting the water from the mills below, etc.

There are now 54 miles of mains in use, giving some 90 percent of the people access to the water. There are 4,090 services in, of which 4,040 are in use and 200 of these metered. The average daily consumption is 3,070,000 gallons, which is 760 gallons per service, 138 per consumer, and 80 per capita of the total population.

Tippecanoe City. Population 1,703. The public water supply was put in by the village in 1897, and has cost to date, together with the electric light plant $28,000. The supply is obtained from driven wells located in the eastern part of the village and near the Miami and Erie canal. There are five 8-inch wells, driven 80 feet deep into a deep bed of sand and gravel. Only three of the wells are in use. The normal level of the water is 10 feet below the surface and this is lowered by pumping to a depth of from 17 to 35 feet, according to the season.

The wells are surrounded by the scattered houses of a small village, and will in time suffer some pollution unless steps are taken to drain off all objectionable refuse.

The water is pumped direct from the wells to the mains by two horizontal, duplex, Smith-Vaile pumps of 500,000 gallons capacity each, and at a pressure of 60 pounds, which is decreased to 55 on most of the mains.

There are 6.0 miles of mains in, which gives some 95 percent of the populaton access to the water. There are 267 services in, all of which are in use, but none metered. The average daily consumption is 75,000 gallons, which is 281 gallons per service, 56 per consumer, and 44 per capita of the total population. A canvass was recently made of this village and it was found that there are 428 houses in the place, 315 of which are supplied with water by the 267 services. From the census, this is four persons per house, using which figure, there are 1260 people using the water, or by allowing five persons per service there are 1,335, a discrepancy of 6 percent, which is certainly allowable in estimates of this character.

Trotwood. Population 214. This is the smallest village, or rather community as it is not incorporated, in the state that has a public water supply. The plant was put in in 1899 by a stock company, formed of nearly all the citizens, to provide primarily for a fire protection only, and has cost to date $3,100. The agitation was occasioned by a very disastrious fire the year previous.

The water supply is secured from two 8-inch wells, driven 26 feet through clay and hard-pan and into a bed of gravel. The water stands in the wells 12 feet below the surface and the level was lowered but little by pumping at the rate of 120 gallons per minute. The water is pumped direct from the wells to a horizontal steel tank by a vertical, duplex, power pump run by a gasoline engine. The tank, engine, pump, and wells are all within the confines of a neat stone building situated at the edge of the village.

The pump was made by C. O. Lucas of Greenville, Ohio, and is fitted with a device by which a certain amount of air can be pumped with the water to the tank and there, under pressure, force the water through the mains when the pump is not running. The pump is a double acting one, with a capacity of 175,000 gallons in 24 hours, working under a pressure of.from 40 to 80 pounds, the limits allowed in the tank. This tank is 24 feet long, 5 feet in diameter and holds 5,000 gallons. It is fitted with a blow-off cock for the regulation of the pressure and the amount of air above the water.

There are 1,800 feet of mains into which some 75 percent of the people have access. There are 22 services in, 16 of which are for sprinkling only, and none metered.

The water is of good quality but it is not in general use for domestic purposes as yet. On account of the few services and the wide range of pressure allowed in the tank, from 80 to 40 pounds, the pump is run for a short time only, each day, and the water in the tank is not so fresh as it would be with a larger consumption.

Troy. Population 5,881. The public water supply was put in by the village in 1884, and has cost to date $125,000. The first supply was obtained from a large well, 25 feet in diameter and 31 feet deep, dug in the sand and gravel which underlies this whole section. This failed to supply the increasing consumption and in 1891 another large well was dug, which was later filled by a flood and not reopened As the consumption increased, five 8-inch wells were driven 20 feet in the bottom of the first large well and the flow considerably increased for a time, but the water soon ran low and they are not of much use now. In 1898 three wells were driven near the old large wells but they were of no value. In the same year five 8-inch wells were driven along the street south of the plant and considerable water found at from 38 to 51 feet below the surface. In 1899 eight 8-inch wells were driven just east of the plant, to a depth of from 38 to 54 feet. The last two sets of wells, 13 in all, furnish the bulk of the water.

The water is pumped direct from the wells by two horizontal, compound, duplex, Laidlaw-Dunn-Gordon pumps of 1,700,000 gallons capacity each. Until March 1898 nearly all of the water was pumped by two Smith-Vaile power pumps of 1,000,000 gallons capacity each, actuated by a 15-inch and 28-inch Victor turbine supplied with water under 16 feet 8 inch head from the hydraulic. This hydraulic was fed from the Miami and Erie canal and a little local territory and furnished an excellent power until March 1898, when a flood washed out the embankment near the power house, damaging the latter and filling up one of the wells as noted above. The average domestic pressure carried is 60 pounds.

There are 14.0 miles of mains in, to which some 90 percent of the people have access. There are 1,002 services in, of which 994 are in use and 78 of these metered. The average daily consumption is 503,000 gallons, which is 506 gallons per service, 101 gallons per consumer, and 86 per capita of the total population.

The water works is located in the northern part of the city where the wells are subject to but little local pollution as yet and the water seems to be of good quality.

Urbana. Population 6,808. There has been no change in the water supply for this city since the special report of the State Board of Health in the 1899 annual report, except in the increased use of the driven wells. These eight wells are 6 inches in diameter, average 40 feet in depth, and obtain their water from an extensive bed of gravel mixed with fine sand. The sand finally worked into the screens of the wells to such an extent that the supply from this source was lessened materially. To overcome this the well casings were drawn and new screens put down and the wells put in use to help out the large dug well.

There are now 20.0 miles of mains in, giving some 85 percent of the people access to the water. There are 960 services in, of which 900 are in use and 18 of these metered. The average daily consumption is 1,170,000 gallons, which is 1,286 gallons per service, 257 per consumer, and 186 per capita of the total population.

The water is at the present time a potable one, but it is in the line of pollution from the sub-surface drainage of the city and it may at some time seriously feel the influence of this drainage, though it is not harmed to any extent by it as yet.

Versailles. Population 1,478. On November 1, 1900, this village secured the approval of the State Board of Health for a public water supply to be obtained from three 8-inch wells located on the banks of Swamp Creek and near the center of the village, though not in the immediate neighborhood of many houses. The wells are driven 30 feet deep through a bed of clay and into gravel, and could furnish an excellent water but for the surrounding population. The water is not of the best but as it is all that can be had, and is so much better than the private well water, its use was permitted. The plant is now being put in and it is expected to be in operation very soon.

Waynesville. Population 723. On November 1, 1900, this village secured the approval of the State Board of Health for a public water supply to be obtained from a number of 6-inch drilled wells located south of the village and near the Little Miami River. The wells are from 40 to 50 feet deep, drilled through various strata of sand and gravel and into limestone, just above which the water is found.

The wells are removed from practically all local pollution and the small amount existing can easily be removed, so that they should furnish an excellent water, much better than the private well supply. Bonds for $30,000 have been sold and a combined electric light and water plant is now being put in.

West Alexandria. Population 740. The public water supply was put in by the village in 1897, and has cost to date $16,000. The supply is obtained from four artesian wells located in the southwestern part of the village. The wells are 6 inches in diameter, two of them 132 feet deep, one 95 feet deep, and one 65 feet deep, and all go through alternate layers of clay, gravel, and hard-pan. It is claimed that the wells will flow with a head of 16 feet above the surface.

Only the natural flow of the wells is utilized, the water being conducted to a receiving basin from which it is pumped to the standpipe by two horizontal, duplex, Smith-Vaile pumps of 1,000,000 gallons capacity each. The basin consists of a covered brick well, 20 feet in diameter, 24 feet deep, with a capacity of 7,500 gallons. The standpipe consists of a steel tank 40 feet high, 16 feet in diameter, and holding 60,000 gallons, placed on a brick tower 60 feet high. The average pressure on the mains is 40 pounds.

There are 2.5 miles of mains in, to which 95 percent of the people have access. There are 91 services in, all of which are in use, and all metered. The average daily consumption is estimated to be 35,000 gallons, which is 385 gallons per service, 77 gallons per consumer, and 47 gallons per capita of the village's population. This consumption, if correct, is very large for a place of this size, especially with all services metered, and it is hardly accountable for unless it is due to the rather excessive summer sprinkling.

West Carrollton. Population 987. The public water supply was put in by the village in 1895 and has cost to date $7,900. The supply is obtained from two 8-inch wells drilled in the low land along the Miami and Erie canal. The wells are 65 feet deep and go through gravel, hardpan, and into a deep bed of sand in which the water is found. The normal level of the water is about 10 feet from the surface and it is lowered to about 30 feet by the highest consumption.

The water is pumped direct to the mains by a horizontal, duplex, McGowan pump of 750,000 gallons capacity. The average pressure is 60 pounds. The pump is located in the mill of the G. H. Friend Paper and Tablet Company, which firm has a ten-year contract with the village under which they are to furnish steam for the pump and keep the same in repair for the use of same and of the water in the wells. The consumption of water in the village is small, but a large amount is used by the paper mill.

There are 2.5 miles of mains in, giving some 90 percent of the people access to the water. There are 89 services in, of which 84 are in use and none metered. The well water seems to be of good quality and is used for domestic purposes wherever available.

Xenia. Population 8,696. The public water supply was put in by a private company in 1887 and has cost to date, as claimed, $200,000. The company now operates under the name of "The Xenia Water Company."

The first supply was obtained by impounding the runoff of a number of springs, located one and one-half miles north of the city. The flow from these is collected in an open reservoir, formed by an earthen embankment, with sheet-piling core-wall, thrown across a small valley and forming a basin one and one-half acres in area. Through the center of the reservoir there is a dividing wall, for convenience in cleaning only. This, as well as the inner side of the dam, is roughly paved. Much of the surface drainage to the reservoir is diverted but some of it is used. Later, near this reservoir, a large well, 75 feet square, was dug 25 feet deep through a bed of clay and hardpan into gravel. The water from this is pumped by a 1,000,000 gallon horizontal, duplex, Worthington pump, to a large stone pump-well, 40 feet in diameter, built in the dividing wall of the reservoir. The combined water of the well and reservoir is then pumped through the mains to a standpipe by two horizontal, compound, duplex, Gordon-Maxwell pumps of 1,500,000 gallons capacity each. It is estimated that the springs will supply 300,000 gallons daily and the well 100,000.

In 1896 these sources were helped out by an additional ground supply secured from six 6-inch wells and three 8-inch, located southwest of the city, just out of the corporation limits. These wells are from 28 to 40 feet deep and go through a bed of clay and into gravel. The normal level of the water is six to eight feet from the surface and it can easily be lowered to the suction limit, indicating a rather weak vein at the above depths. A test well is now being put down into the rock, which is found at 60 feet, in hopes of securing a more abundant supply.

This last set of wells is pumped by a 1,000,000 gallon horizontal compound, duplex, Deane pump, direct to the mains and standpipe. This station supplies some 175,000 gallons a day for a few days each week in the summer and fall, and is not used in the winter.

The standpipe is 115 feet high by 20 feet in diameter, with a capacity of 270,000 gallons, and furnishes, when full, an average pressure on the mains of 55 pounds.

There are 20 miles of mains in, to which some 90 percent of the people have access. There are 700 services in, of which 670 are in use and 50 of these metered. The average daily consumption is 350,000 gallons, which is 522 gallons per service, 134 per consumer, and 42 per capita of the total population.

SUMMARY.

The data in the previous section have been summarized in Table VIII:

The above table contains a brief description of the 27 public water supplies of the Miami watersheds.

The total population in these cities and villages is 239,000, or an average of 8,852 per supply. Twenty-three of the plants are under municipal ownership and control, one under joint municipal and private control, and three are owned and controlled by private corporations.

The first water-works for Blanchester was put in by the village, but the supply of water from wells failed almost immediately and the village was without water for nearly two years, as there were no more funds available to seek a new supply.

In order to get fire protection a private company was formed and a franchise secured from the village according to which the company agreed to furnish a supply of water for the pumps in return for which they were to collect all the private water rents. This company, the Blanchester Water and Light Company, put in the impounding reservoir at a cost of $6,000. The franchise is to run for 15 years from 1899, and the village can purchase at the expiration of the franchise only. The water rates are fixed by the franchise, which also specifies that the water shall be taken from the reservoir.

The Trotwood water-works was put in by a stock company formed of citizens of the village. This company has no franchise as the village is not incorporated and none could be granted. The plant was put in by sufferance alone. The mains are in the county and township roads, the verbal permit of the commissioners and trustees having been secured.

The franchise of the Urbana water-works company expired in 1899 and no new one has been secured since that time. There has been considerable friction between the city and the company and the terms of settlement are uncertain. The company still supplies water for the citizens, collecting the rent for the same, and this condition may hold for some time.

Xenia is supplied with water by the Xenia Water Company, operating under a 20 years' franchise granted July 19, 1886. The city may purchase the plant at any time after the expiration of the first ten years. Rates are fixed by the franchise. The water is to be taken from wells or filtering galleries near the Little Miami River or Cæsar's Creek, with direct connection to either stream for fire protection only. As a matter of fact neither stream is used, but the water is secured from an entirely foreign source.

The very recent growth of the public sentiment in favor of water works is shown by the fact that the average age of the plants is only 11 years. Only one plant was installed during the decade from 1860 to 1870; four from 1870 to 1880, six from 1880 to 1890, and sixteen since 1890.

The total cost of the 25 plants which have been completed is $4,352,805, or an average of $174,112 per plant. In order to give a better idea of the relative cost of these plants, the per capita cost was computed; that is, the total cost of the water-works plant complete for every inhabitant of the city, or village. This was found to run from $8 to $32.02, with an average of $19.32.

The low cost of the West Carrollton plant is due to several causes, among which are the ease with which water was secured, small amount of mains, and the absence of a standpipe or reservoir and of a pump house.

The high cost of the Piqua plant is due to the fact that a long hydraulic was constructed to furnish both water and power for the water works and power for outside industries.

The high cost for Sidney was brought about by the abandonment of the old surface supply and the installation of a ground supply.

With these exceptions the per capita cost lies within very reasonable limits, the variations being easily explained by the character of the water works and the greater or less difficulty in securing a supply.

As would be expected from the topography of these watersheds pressure is supplied by direct pumping in ten cases, by pumping to standpipes and tanks in twelve cases, and by pumping to reservoirs in three cases only. There are no gravity supplies. Compressed air instead of elevation furnishes the pressure in the case of the Trotwood tank.

The average size of the standpipes and tanks is 211,667 gallons. The three supply reservoirs have a capacity of 98,000, 2,000,000,000 and 7,000,000 gallons respectively. There are ten reserve and impounding reservoirs, collecting wells, ranging in size from 55,000 gallons to 7,500,000 gallons.

The average pressure at which the water is supplied varies from 24 to 120 pounds per square inch, with an average of 58 pounds. Sixty pounds seem to be the standard domestic pressure and most of the variations below this figure are due to irregular topography and to too small mains.

In all, there are 463.0 miles of water mains in, an average of 18.5 for each water-works.

The percent of population accessible to the mains runs from 75 to 95, the average being 89.4. The percentage of the total population of all the towns which is accessible to the mains is 90.2, a little greater than the average percent, as the larger cities and villages usually have more complete systems. The total number of services that have been put in is

30,467, or 1,219 for each plant. Of these the total number in use is 26,866, an average of 1,075 per system.

There are in all 7,652 meters in use, or an average of 306 for each water-works, or 425 for each water-works that has any meters whatsoever. Seven of the supplies do not have a metered service. West Alexandria has every service metered. This village together with Dayton, Eaton, Greenville, Hamilton and Norwood, constitute all the supplies in which meters are at all extensively used.

The total pumping capacity of the 25 water-works is 91,825,000 gallons per 24 hours, or an average of 3,673,000 gallons for each. It is interesting to note that the total pumping capacity of the several supplies varies from 1.6 times the average daily consumption to 57 times. For the 20 in which the consumption could be estimated the average excess of the total pumping capacity over the average daily consumption is fourteenfold. This high figure is due to the large excess found in the new plants, as an allowance for future growth. It would seem that for a direct pumping plant, with no, or moderate storage facilities, the total pumping capacity should be at least four to six times the average daily consumption and in more than one unit, so as to allow for short periods of excessive consumption and for accidents. Urbana, Bellefontaine, and Piqua each have a total pumping capacity only a little more than two times the average daily consumption; and Hamilton has only 1.6 times as much. Hamilton has a supply reservoir nearly seven times its average daily consumption, and Bellefontaine one of three times its average daily consumption, so that in these cases the deficiency is not felt so severely. Bellefontaine is now increasing its capacity by a new 2,500,000 gallon pump, and Hamilton has the matter under way.

Both the Urbana and Piqua plants would be seriously handicapped by an accident to one of their pumps, or by a large fire occurring at the time of the maximum consumption.

The average daily consumption for the 20 plants where this was obtainable is 833,090. The average daily consumption per service is 584 gallons; per capita of the total population, 67 gallons; and per consumer it is 116 gallons. There are not enough metered supplies to bring out the reduction in consumption due to these devices.

RATES.

The rates at which water is sold for general domestic purposes, together with the meter rates, in the 25 cities and villages having public water-works in operation, is given in detail in Table IX.

It is almost impossible to make a comparison of the cost of water for ordinary uses in the different places, owing to the variation in the way in which the charges are made. For ordinary house use, that is, one yard hydrant or one inside faucet, the charge is based, in the various towns, according to the number of rooms, number of faucets, number of persons, and finally with no specifications whatever.

Missing Page

The rates for bath tubs, water-closets, wash-basins, etc., are much more uniform and a very fair idea of the variation in price can be secured, but the charges for street and lawn sprinkling are made on so many different bases that comparisons are almost impossible. To overcome this difficulty a standard case has been assumed, consisting, as is shown in the table, of an 8-room house situated on a lot 50 by 100 feet, and valued at $5,000. This house is supposed to be occupied by one family, of six persons, and to be fitted with one kitchen sink, one bath tub, one water closet, one wash-basin, and one yard hydrant for sprinkling yard and street. It also has a stable in which are kept one horse and one carriage. For this case there has been computed as carefully as possible, from the published schedule of rates, the annual charge in each city and village where the data were sufficient.

For the 21 given, the average was $17.30 with a minimum of $10.00 and a maximum of $22.00. For the 18 municipal plants the average was $17.06, and for the three private $18.68. It will be interesting to note that for 20 cases in the Muskingum watershed the average rate for this same standard house was $19.63 and for 13 municipal plants it was $17.94 and for the seven private, $22.78. Between the rates for the plants owned by the municipalities there is a remarkable agreement in the averages, while in the private rates there is quite a wide discrepancy.

Many different methods are also used in specifying the rates to be charged for metered water and it was necessary to make these conform to the standard as given in the table. On this account, in a few cases the figures are only approximations, but the general rate is believed to be correct.

For the minimum use of water the meter rate varies from 7 to 40 cents per 1,000 gallons, and for the maximum use from 3 to 20 cents per 1,000 gallons. It does not seem possible that very much attention is paid to the actual cost of supplying the water when these rates were established.

The majority of the meter rates are based on a sliding scale depending on the amount of water used, but a few charge the same price per 1,000 gallons for both the large and small consumers. It is also customary to establish a minimum charge for meters in the shape of an annual rent for the meter, or a set minimum rate which must be paid whether the water is used or not, this latter usually varying with the size of the meter.

VII. DAMS AND WATER-POWERS.

As in the Muskingum watersheds, so there has been for the Miami rivers an enormous decline in the use and development of water-power, especially among the smaller powers on the minor streams. The decline in the Little Miami watershed is only apparent in the smaller number of mills, as the horse-power in use has diminished but little owing to the more complete development of some of the larger powers, especially the one at King's Mills.

In gathering the information concerning the use and development of the water-power in the Miami watersheds, the same methods were used as were employed in the investigations of the previous year. The data are from personal inspections and from reports of owners and operators in nearly every case and can be considered reliable to a degree sufficient for work of this character. The estimates on the horse-power available are not exact owing to the uncertainty regarding the condition of the wheels. The estimates on pond area are rather crude and are given only as a guide to the amount of storage available.

The areas of tributary watersheds were obtained by planimeter measurements from the State Board of Health map of Ohio.

Owing to the large area to be gone over a number of small and little-used powers were probably overlooked. This is especially true in Logan county, where there are one or two small mills on the head-waters of both the Great Miami and Mad rivers, which were not visited on account of their unimportance and inaccessibility.

Of the dams and water-powers investigated, the principal data are given in Tables X and XI.

In the Great Miami watershed there are given 53 dams, only two of which are not in use; five divert water for the supply of the Miami and Erie canal, and 48 furnish water-power, two dams supplying both the canal and water-power. The 48 dams furnish some 89 mills, with a total horse-power of 4,158 or an average of 47 horse-power per mill. In 1880, according to the United States census, there were in the Great Miami watershed 218 mills, using some 7,191 horse-power, or 33 horse-power per mill. In the 20 years there was a decline of 59 percent in the number of mills, but only of 42 percent in the total horse-power in use.

In the Little Miami watershed the table gives 24 dams, two of which are not in use and the 22 remaining supply power for 28 mills, using 1,803 horse-power, or 64 horse-power per mill. In 1880 there were 59 mills using 1,956 horse-power, which is 33 per mill. This is a decline of 52 percent in the number of mills, but only 8 percent in the total horse-power in use.

On the Miami and Erie canal, within the Great Miami watershed, there are given 14 mills using 860 horse-power, or 61 per mill. In 1880

Missing Page

there were 48 mills using 2,011 horse-power from the canal. If the above figures are correct there was a decline, in twenty years, of 70 percent in the number of separate powers and of 57 percent in the total horse-power in use.

The decline in the use of water-power on the canal is no doubt mainly due to the falling off of navigation, which left many of the mills without sufficient means of obtaining supplies or of disposing of their product. The general tendency to use the more reliable steam power in preference to water-power and the increase of competition, were also factors in the abandonment of the small water powers.

In the water powers supplied from the streams direct the principal and almost only cause in a number of places was the decrease in runoff from the tributary watershed and the increase in the variation of this flow. This is a cause which has been expounded at such length that there is no further need for discussion here. It is altogether too true that the rapid deforesting of the state has seriously affected the regularity of the flow of the streams. Where there was formerly a fairly constant stream of water flowing there is now a variable one, dry in summer and with frequent floods in the spring.

The other factors which enter into the question of the decline in the use of water-power are the filling up of the reservoirs and impounding areas and the natural deterioration of the plants.

The first of the above is one which cannot be avoided and one which requires radical treatment to remedy the evil affects. With the greater variation in the flow of the streams and with a rapidly decreasing storage capacity the water-power available was most seriously affected. Instead of being able to store the night flow for use during the day, it is necessary to depend upon the average daily flow of the stream.

The natural wearing out of the plants from long use, coupled with lack of means for repair and renewal, is causing many of the smaller plants to be abandoned. The old school millers are dying off and the younger men, failing to find the operation of a small isolated mill remunerative enough, abandon it and seek other fields for employment.

It will be noticed from Tables X and XI that the water-power is employed in both these watersheds in a much greater variety of work than in the other watersheds. The isolated powers are still mainly used in flour, feed and saw mills, but the power developed by the hydraulics in Dayton, Middletown, and Hamilton, are used in a number of different industries. The large paper mills of the two last named places derive at least some of their power from this source. In a few cases where the water-power is not sufficient, steam has been substituted and the water of the privilege used for boiler supply, washing purposes, etc.

The Hamilton hydraulic supplies some twelve mills and factories with 434 horse-power. The water is brought from the river by a race five miles long and is distributed to the various powers in such a way that some have the full head of 26 feet from race direct to the river, a few have a 13 foot head between the race and a tail race, emptying into the old river bed; the remainder having 18 feet head, from a second level to the river. The full head of this last group is not used at present, there being 7½ feet fall between the first and second levels.

The next important power is found at Middletown, where the state dam sends a part of the flow of the river to a hydraulic which now supplies 658 horse-power to six plants, including the city water-works. The fall is obtained between the hydraulic and the river direct and varies from 17 to 18 feet according to the location of the power. This power is good for from ten to twelve months in the year and is one of the best in the district.

At Miamisburg some 330 horse-power is furnished to three mills by a dam in the Great Miami River at West Carrollton. In consideration of supplying a certain amount of water to the canal, this water-way is used as a race for a portion of its length.

At Dayton a hydraulic from Mad River supplies fifteen manufacturing establishments with 384 horse-power, not all of which is in use however. The fall is obtained between different levels of the hydraulic, between these and the canal and between the latter and the river. The water is not sufficient at all times for the power rented and all of the latter is not used.

Above Dayton, at Harshmanville, Mad River furnishes some 300 horse-power to a number of small mills, but at the present time only 40 horse-power is used and this in a shoe factory.

At Piqua a hydraulic supplied principally from the canal, at one time furnished power to a large number of mills. At the present time, however, it only furnishes some 210 horse-power to the city water-works.

In the Little Miami watershed by far the most important power is that developed at King's Mills by the King Powder Company. At first the water was conducted through a long race to a number of isolated mills scattered along the river bank for two miles or more. Now it is conveyed to a central power plant where it is used to generate electricity, which is in turn conveyed to the isolated mills necessary in the manufacture of powder.

AA. STREAM GAGING.

The work in stream gaging has been carried on along the same lines as first laid down with the assistance of Mr. F. H. Newell and Mr. H. A. Pressey, of the United States Geological Survey. To these gentlemen and to Prof. C. N. Brown of the Ohio State University, this Board wishes to express its appreciation for their assistance and coöperation in this work.

During 1900 it was possible to work up the daily discharge of the Sandusky and Maumee rivers for 1899 and 1900 and the results of this work, together with the usual report on the Scioto and Olentangy rivers, is presented in the following tables and plates.

Owing to changes in the stream bed and certain obstructions to the flow it was not possible to work up the discharge of the Sandusky at Fremont for the present report, and the flow of this stream at the Mexico station only is given.

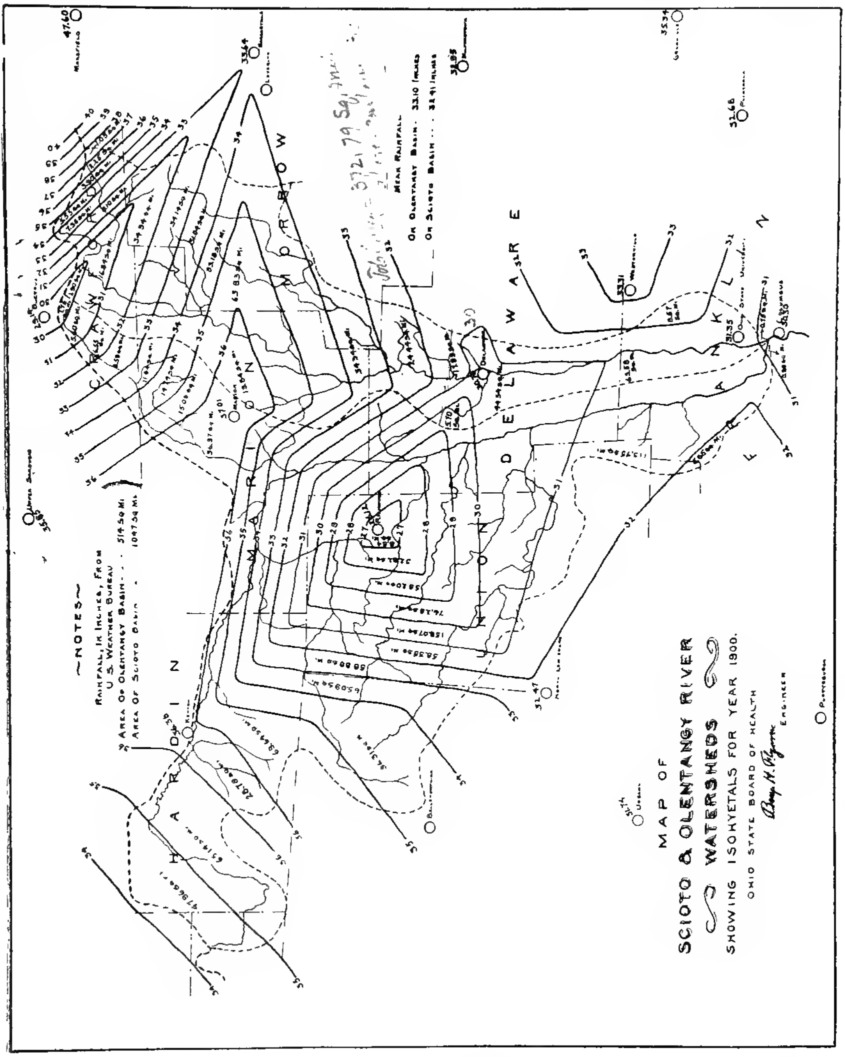
SCIOTO RIVER (ABOVE COLUMBUS) AND OLENTANGY RIVER.

The daily stream heights for these streams were taken by persons in the employ of the Ohio State Board of Health, but, as formerly, the computation of the discharge was made under the direction of Prof. C. N. Brown, of the Department of Civil Engineering of the Ohio State University. The rainfall statistics for the first five months of the year were also worked up under the same direction, but the data for the remainder of the year were compiled by the engineering department of the Board.

As was explained in the last annual report of the Board, the rainfall over these watersheds is secured from the reports of the United States Weather Bureau. The reading of the monthly rainfall for all the stations in the watershed and for those adjacent to the same are taken and the isohyetals, or curves of equal rainfall, plotted on the watershed map, then the areas of equal rainfall are measured by a planimeter and the mean rainfall over the entire watershed secured. Except in a few cases of extreme variation in the rainfall, the isohyetals for every variation of one-fourth inch in rainfall are put in, so as to make a very close estimate on the mean rainfall of the whole district. It is not possible to put in the twelve maps with the monthly rainfall, but to illustrate the principle the yearly rainfall has been plotted and the isohyetals drawn for each inch of variation in the rainfall instead of the one-fourth inch curves as used in the monthly maps.

The mean yearly rainfall as taken from this map was found to be slightly different from that secured by the addition of the figures of mean monthly rainfall. This is probably due to the inaccuracy of the direct yearly estimate due to the absence of complete records from a

PLATE 14.


MAP OF
SCIOTO & OLENTANGY RIVER
WATERSHEDS
SHOWING ISOHYETALS FOR YEAR 1900.
OHIO STATE BOARD OF HEALTH
Engineer
—NOTES—
Rainfall, in Inches, From U. S. Weather Bureau
Area Of Olentangy Basin . . . 514 Sq Mi
Area Of Scioto Basin . . . 1047 Sq Mi
Mean Rainfall
On Olentangy Basin . 33.10 Inches
On Scioto Basin . . . 32.91 Inches
MORROW
MARION
DELAWARE
UNION
FRANKLIN
HARDIN

number of stations, but which gave data for many of the monthly curves. The discrepancy was not enough to discredit the method in any way, however, but rather to strengthen it.

The following table, XII, shows the rainfall at the stations used and the equivalent rainfall for each watershed as determined by the method outlined above.

TABLE XII — RAINFALL ON SCIOTO AND OLENTANGY WATERSHEDS FOR 1900.

Place.	Jan.	Feb.	March.	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Upper Sandusky	2.69	4.14	3.25	2.20	3.05	2.57	4.37	5.06	1.98	2.62	2.57	1.35	35.85
Bucyrus	1.60	2.85	2.00	......	3.27	4.64	3.40	....	2.10	....	....	....	......
Mansfield	2.89	4.75	4.30	4.85	3.50	4.15	7.88	4.65	2.23	2.15	4.63	1.62	47.60
Kenton	3.11	4.29	2.31	2.30	1.39	5.04	3.67	3.41	1.52	3.67	4.66	1.01	36.38
Marion	3.35	3.86	2.47	3.12	1.33	5.64	3.13	4.52	2.99	1.84	3.45	1.31	37.01
Bangorville	2.53	4.19	2.79	2.16	1.73	2.45	3.84	5.02	2.25	1.74	3.43	1.51	33.64
Bellefontaine	1.60	2.55	2.12	2.78	2.61	5.65	3.76	3.43	2.64	2.78	2.75	....	......
Richwood	2.16	3.85	1.32	1.23	1.02	2.49	3.06	3.38	1.08	1.87	3.72	0.94	26.12
Delaware	2.59	3.56	2.44	2.58	1.25	1.99	3.89	5.69	0.62	1.27	3.77	1.05	30.70
Milfordtown	2.24	2.65	3.17	2.10	1.45	2.45	5.33	4.76	2.43	1.62	3.42	1.33	32.95
Sidney	2.94	3.56	2.99	1.80	1.90	3.82	2.70	3.98	2.53	5.21	3.08	1.24	35.75
Urbana	3.14	3.25	2.01	2.02	2.36	4.00	2.42	3.33	2.39	1.99	3.68	1.15	31.74
North Lewisburg	2.97	4.00	2.25	2.45	1.90	2.20	3.70	4.20	1.25	1.85	4.45	1.25	32.47
Westerville	2.63	3.01	2.44	2.80	1.86	2.51	3.66	5.20	1.80	2.24	4.06	1.10	33.31
Plattsburg	2.91	3.65	2.00	1.60	1.48	2.44	5.80	2.65	4.12	2.33	4.88	1.45	35.31
Columbus	3.01	3.30	2.59	1.76	1.82	2.45	3.89	3.02	0.97	2.86	3.71	0.92	30.30
Ohio State University	2.78	3.41	2.56	2.30	1.64	4.10	3.27	3.28	1.57	2.11	3.28	1.05	31.35
Pataskala	2.92	4.21	3.03	2.41	2.98	1.78	2.77	3.05	1.82	1.98	4.45	1.28	32.68
Granville	2.85	3.79	2.89	3.08	1.56	2.42	4.55	3.80	3.12	2.15	3.79	1.34	35.34
Equivalent for Scioto	2.57	3.62	2.04	2.22	1.54	3.77	3.43	3.89	1.62	2.32	3.81	1.13	31.96
Equiv. for Olentangy	2.52	3.52	2.46	2.96	1.76	3.86	3.44	4.81	2.10	1.77	3.66	1.28	34.15

The monthly discharge of the streams is given in Tables XIII and XIV, which were prepared after the usual standard of the U. S. Geological Survey, but with the addition of the ratio of the runoff to the rainfall.

TABLE XIII — MONTHLY DISCHARGE OF OLENTANGY RIVER AT COLUMBUS, 1900.

Drainage area 514 square miles.

Month.	Discharge in Second-f't			Total in acre-feet.	Run-off.			
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.	Rainfall in inches.	Ratio.
1900.								
January	2,580	366	691.0	42,504	1,345	1,551	2.52	.615
February	2,450	305	763.0	42,385	1.485	1.546	3.52	.439
March	7,492	347	1,090.0	67,029	2.121	2.445	2.46	.994
April	2,150	95	560.0	33,310	1.089	1.215	2.96	.410
May	142	55	77.0	4,731	0.150	0.173	1.76	.098
June	427	25	121.0	7,220	0.235	0.263	3.86	.068
July	427	8	74.0	4,546	0.144	0.166	3.44	.048
August	1,630	8	240.0	14,747	0.467	0.538	4.81	.112
September	247	8	34.0	1,997	0.066	0.073	2.10	.035
October	25	8	8.7	536	0.017	0.020	1.77	.011
November	1,030	8	124.0	7,404	0.241	0.270	3.66	.074
December	305	55	111.0	6,428	0.216	0.250	1.28	.195
Year	7,492	8	322.0	232,837	0.627	8,510	34.14	.249

TABLE XIV—MONTHLY DISCHARGE OF SCIOTO RIVER AT COLUMBUS, 1900.

Drainage area 1047 square miles.

Month.	Discharge in Second f't.			Total in acre-feet.	Run off.			
	Maximum.	Minimum.	Mean.		Sec.-ft. per sq. mile.	Depth in inches.	Rainfall in inches.	Ratio.
1900.								
January	4,945	75	1,034	63,574	0.990	1.141	2.57	.444
February	3,300	407	1,455	80,799	1.390	1.450	3.62	.399
March	9,165	556	2,131	131,012	2.030	2.351	2.04	1.151
April	2,150	430	1,042	62,011	1.000	1.113	2.22	.501
May	362	92	182	11,173	0.170	0.201	1.54	.130
June	479	11	149	8,842	0.142	0.159	3.77	.042
July	455	11	54	3,342	0.052	0.060	3.43	.017
August	407	5	104	6,401	0.100	0.115	3.89	.030
September	75	1	14	813	0.013	0.015	1.62	.009
October	143	9	25	1,555	0.024	0.028	2.32	.012
November	1,209	11	225	13,374	0.215	0.240	3.81	.063
December	556	35	139	8,527	0.132	0.153	1.13	.135
Year	9,165	1	541	391,423	0.516	7.026	31.96	.220

The daily discharge is shown graphically in the following plates:

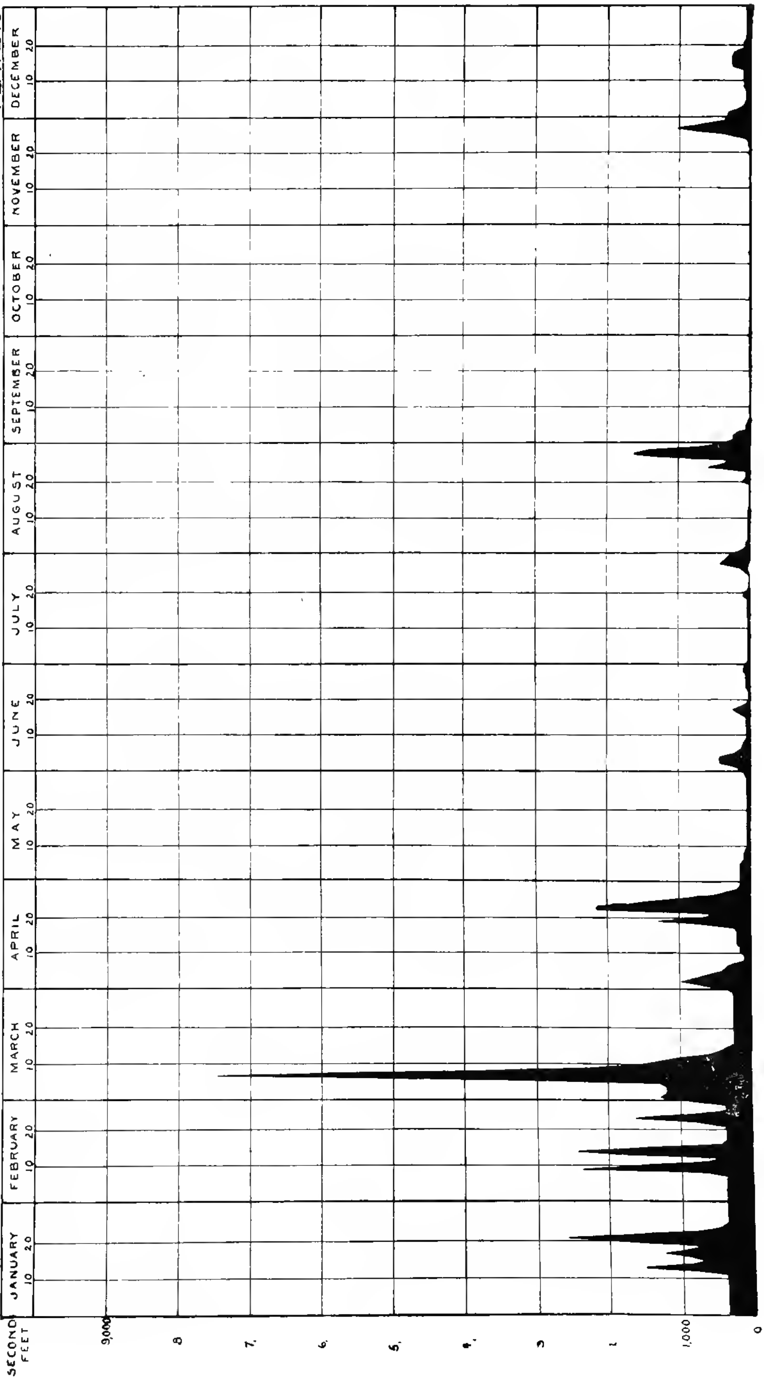
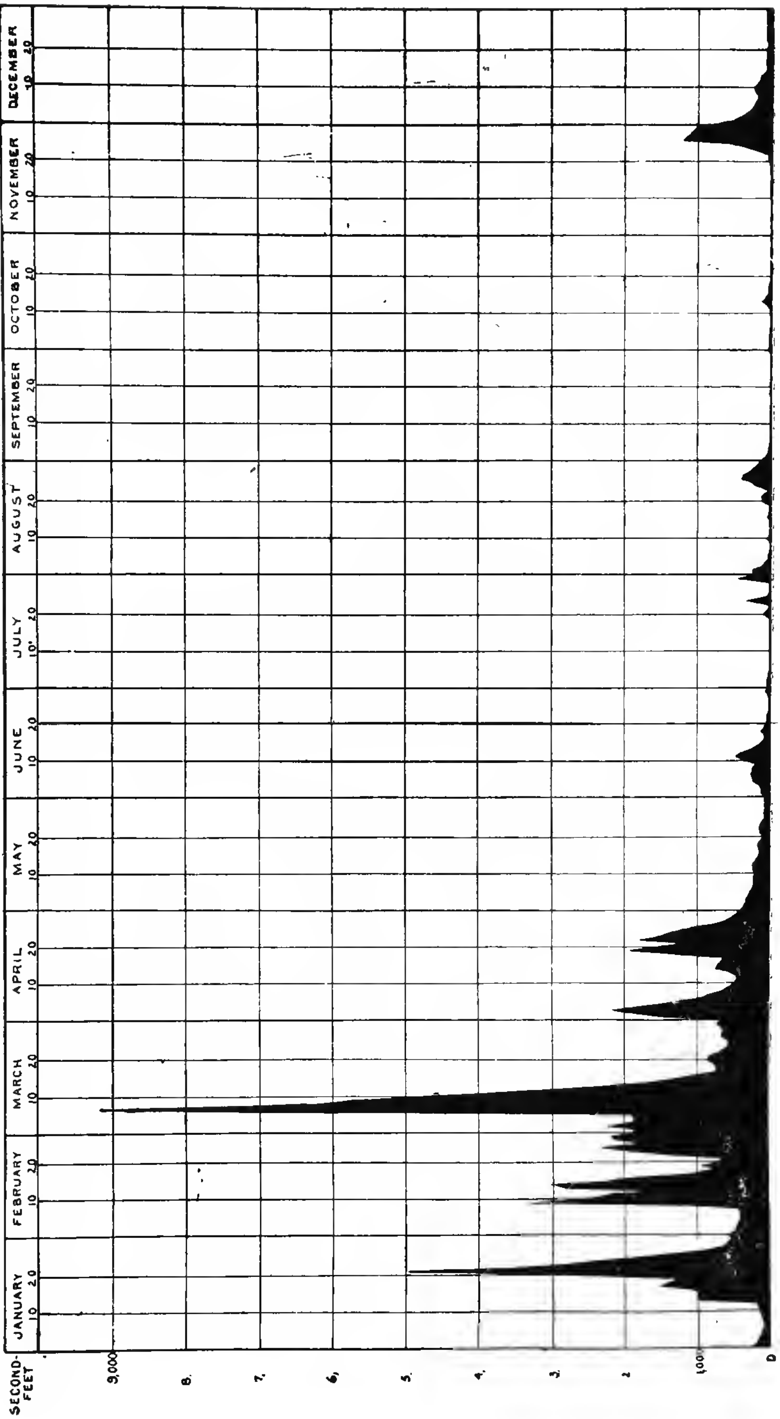


PLATE 15

DAILY DISCHARGE OF OLENTANGY RIVER AT COLUMBUS, OHIO, 1900.

PLATE 16

DAILY DISCHARGE OF SCIOTO RIVER AT COLUMBUS, OHIO, 1900.



SANDUSKY RIVER.

The daily readings of the stream heighth of the Sandusky River at Mexico date from November, 1898, to November, 1900, when the gage was destroyed and the station abandoned. From time to time meter gagings of this stream have been made, but not until this year were enough data secured to make a discharge curve for it at this point.

Owing to the lack of facilities it was impossible to estimate the rainfall by any means except that of averaging the monthly records of the various stations in and near the watershed. For the watershed above Mexico six stations are used and in the same table there are given two other stations, with a separate average of the eight for use at such time as it is possible to get the discharge at the Fremont station.

The monthly discharge of this stream is shown in TableXVI, and the daily discharge is shown graphically in Plates 17 and 18.

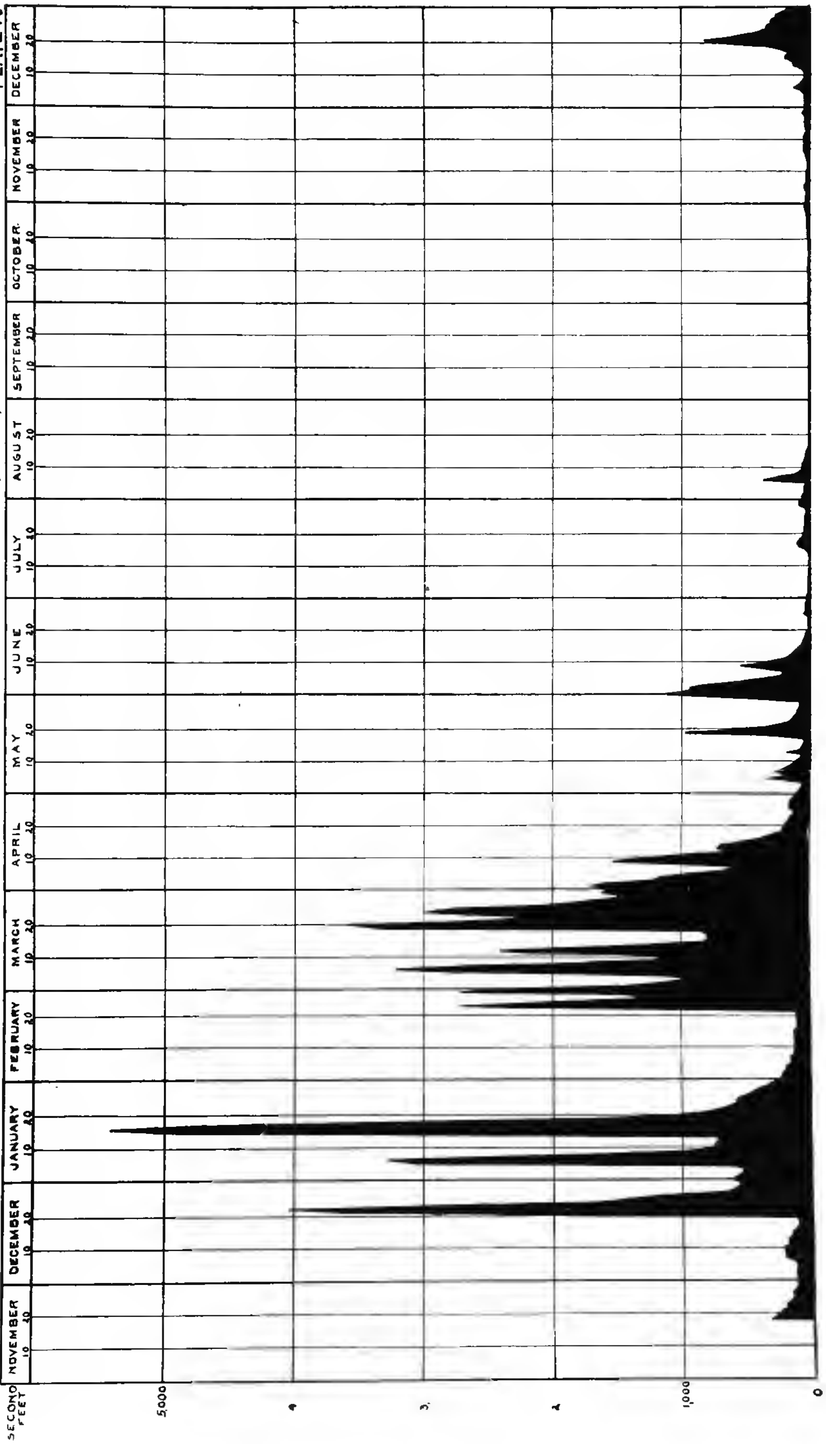
TABLE XVI — MONTHLY DISCHARGE OF SANDUSKY RIVER AT MEXICO, 1898-1900.

Drainage area 776 square miles.

Month.	Discharge in Second-feet			Total in Acre-feet.	Run off.			
	Max.	Min.	Mean.		Sec-ft. per sq. mile.	Depth in inches.	Rain-fall in inches.	Ratio.
1898.								
December ..	4,035	100	727.4	44.726	0.950	1.090	2.65	.411
1899.								
January	5,410	240	1,515.6	93,222	1.953	2.253	3.29	.684
February ...	2,725	100	636.4	35,344	0.820	0.854	2.21	.386
March	3,580	795	1,871.1	115,049	2.424	3.714	4.84	.767
April	1,730	100	600.2	35,714	0.773	0.856	1.44	.594
May	1,145	45	626.6	13,933	0.292	0.334	4.55	.073
June	935	6	207.5	12,347	0.267	0.297	2.95	.100
July	100	4	31.7	1,949	0.040	0.040	4.82	.008
August	375	3	43.9	2,699	0.056	0.066	1.86	.035
September ..	6	2	2.9	173	0.003	0.003	2.34	.001
October	30	2	8.9	547	0.011	0.011	2.22	.005
November ..	45	12	23.9	1,422	0.030	0.030	2.28	.013
December ...	655	30	170.8	10,502	0.220	0.230	3.20	.072
Year	5,410	2	496.6	322,901	0.640	8.688	36.00	.241
1900.								
January	2,245	8	655.5	40,581	0.844	0.974	2.22	.439
February ...	2,380	125	888.9	49,367	1.145	1.192	4.18	.285
March	4,870	270	1,407.0	86,513	1.813	2.093	2.64	.793
April	1,355	180	686.2	40,832	0.884	0.984	2.84	.340
May	180	20	88.4	5,436	0.114	0.134	2.57	.521
June	445	80	161.5	9,610	0.208	0.228	3.94	.578
July	410	6	78.7	4,839	0.101	0.121	4.72	.256
August	1,560	4	242.6	14,917	0.312	0.362	4.76	.076
September ..	125	4	38.3	2,279	0.049	0.058	2.04	.028
October	270	8	70.1	4,310	0.090	0.100	2.53	.039

Missing Page

PLATE 17



DAILY DISCHARGE OF SANDUSKY RIVER AT MEXICO, OHIO, 1898-9.

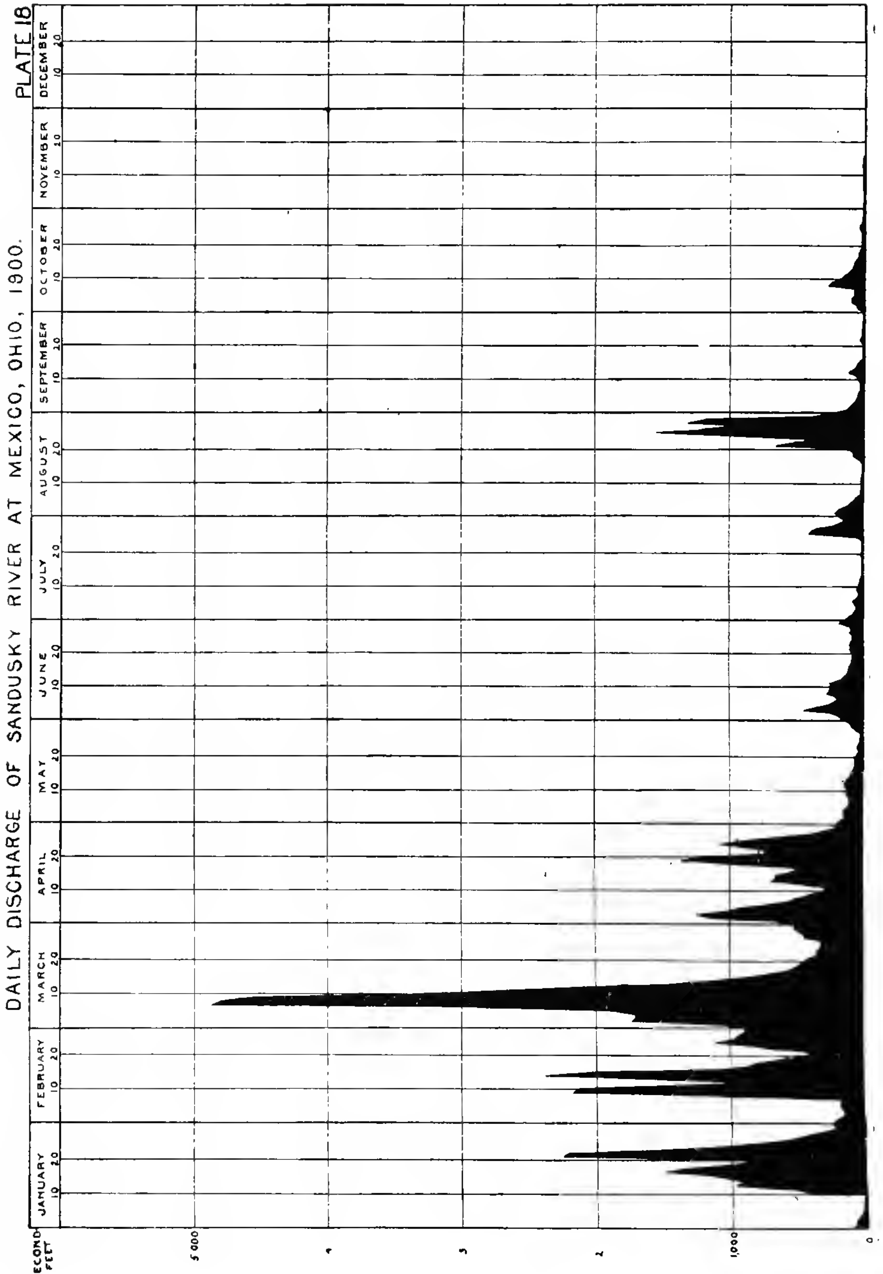


PLATE 18

DAILY DISCHARGE OF SANDUSKY RIVER AT MEXICO, OHIO, 1900.

Missing Page

At Mexico, where the above gaging station is located, the Sandusky River has a watershed of 776 square miles. This district consists of rolling farm land in a rather high state of cultivation. There are very few tracts of timber, of any size, left and the fields are fairly well drained by ditches and tiling.

There are six small dams in the river above the gaging station, but they store very little water and seem to have no perceptible influence on the flow at Mexico.

MAUMEE RIVER.

The gaging station on this stream was placed at Waterville, the first available place above the influence of back-water from Maumee Bay. This station was also established in November, 1898, by the Board, working in connection with the U. S. Geological Survey and the readings are still being taken.

The mean monthly rainfall on this watershed was secured by averaging the depth reported from 21 stations within or neighboring to the drainage basin. It is recognized that the method used on the Scioto and Olentangy is much more accurate, but the time and facilities available would not allow its use on these districts. On the other hand this method of simply averaging the data from scattered stations is the one in general practice and it can be safely asserted that there are but few runoff data extant where as many stations in proportion to the area are available.

Table XVII gives the rainfall stations used and the mean found from these.

The monthly discharge of this stream for the portion of 1898 and for 1899 and 1900 is given in Table XVIII, and the daily discharge is shown by Plates 19 and 20.

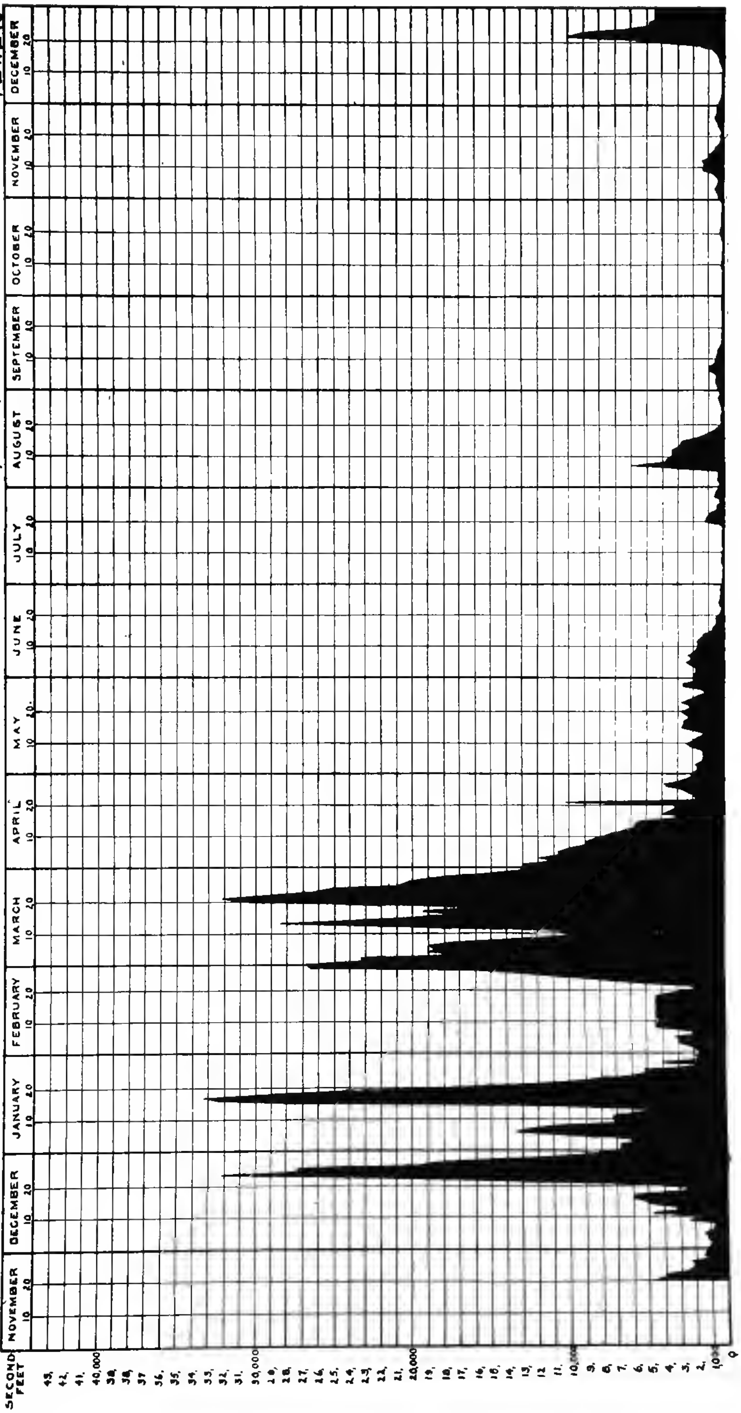
TABLE XVIII — MONTHLY DISCHARGE OF MAUMEE RIVER AT WATERVILLE, 1898-1900.

Drainage area 611 square miles.

Month.	Discharge in Second-feet.			Total in Acre-Feet	Run off.			
	Max.	Min.	Mean.		Sec-ft. per sq. miles.	Depth in inches.	Rain-fall in inches.	Ratio.
1898.								
December .	32,120	680	8,203.4	504,407	1.325	1.525	2.41	.632
1899.								
January ..	33,250	780	10,979.0	675,072	1.796	2.070	2.60	.796
February .	26,765	1,310	6,301.2	349,950	1.080	1.070	2.14	.500
March ...	32,100	8,700	19,431.4	1,194,790	3.180	3.660	4.39	.833
April	12,960	1,800	6,027.5	358,661	.986	1.095	1.11	.986
May	2,750	1,200	1,990.0	352,360	.325	.375	3.66	.102
June	2,450	150	1,057.3	62,814	.173	.203	1.88	.108
July	1,200	3	285.3	17,536	.046	.046	4.36	.011
August ...	4,940	70	1,362.2	43,758	.223	.253	2.09	.121
September	990	20	259.0	15,411	.042	.042	2.40	.018
October ..	150	5	48.1	2,955	.007	.007	2.51	.003
November	1,310	40	521.0	31,001	.085	.085	2.12	.040
December .	9,950	10	2,323.2	142,847	.380	.450	3.08	.146
Year	33,250	3	5,211.7	3,017,155	.689	9.356	32.34	.227
1900.								
January ...	10,200	1,200	5,053.9	310,752	.827	.947	1.25	.757
February .	18,985	2,450	7,943.9	441,180	1.300	1.342	4.50	.298
March	42,750	2,600	15,609.7	959,803	2.554	2.942	2.13	1.381
April	13,965	2,600	8,149.1	484,904	1.330	1.480	2.40	.617
May	3,050	200	937.7	57,657	1.530	1.760	2.65	.664
June	6,320	680	3,443.6	204,907	.563	.623	4.30	.145
July	5,120	300	2,093.5	128,724	.342	.392	4.89	.080
August ...	1,930	5	562.7	34,598	.092	.104	3.56	.029
September	250	5	26.8	1,596	.004	.004	1.45	.003
October ..	250	5	40.6	2,499	.006	.006	2.80	.002
November	9,700	10	2,619.0	155,840	.428	.478	3.89	.123
December	6,320	70	1,508.7	92,766	.246	.286	.83	.344
Year	42,750	5	4,665.7	2,275,226	7,635	10,364	34.65	.299

PLATE 19

DAILY DISCHARGE OF MAUMEE RIVER AT WATERVILLE, OHIO, 1898-9



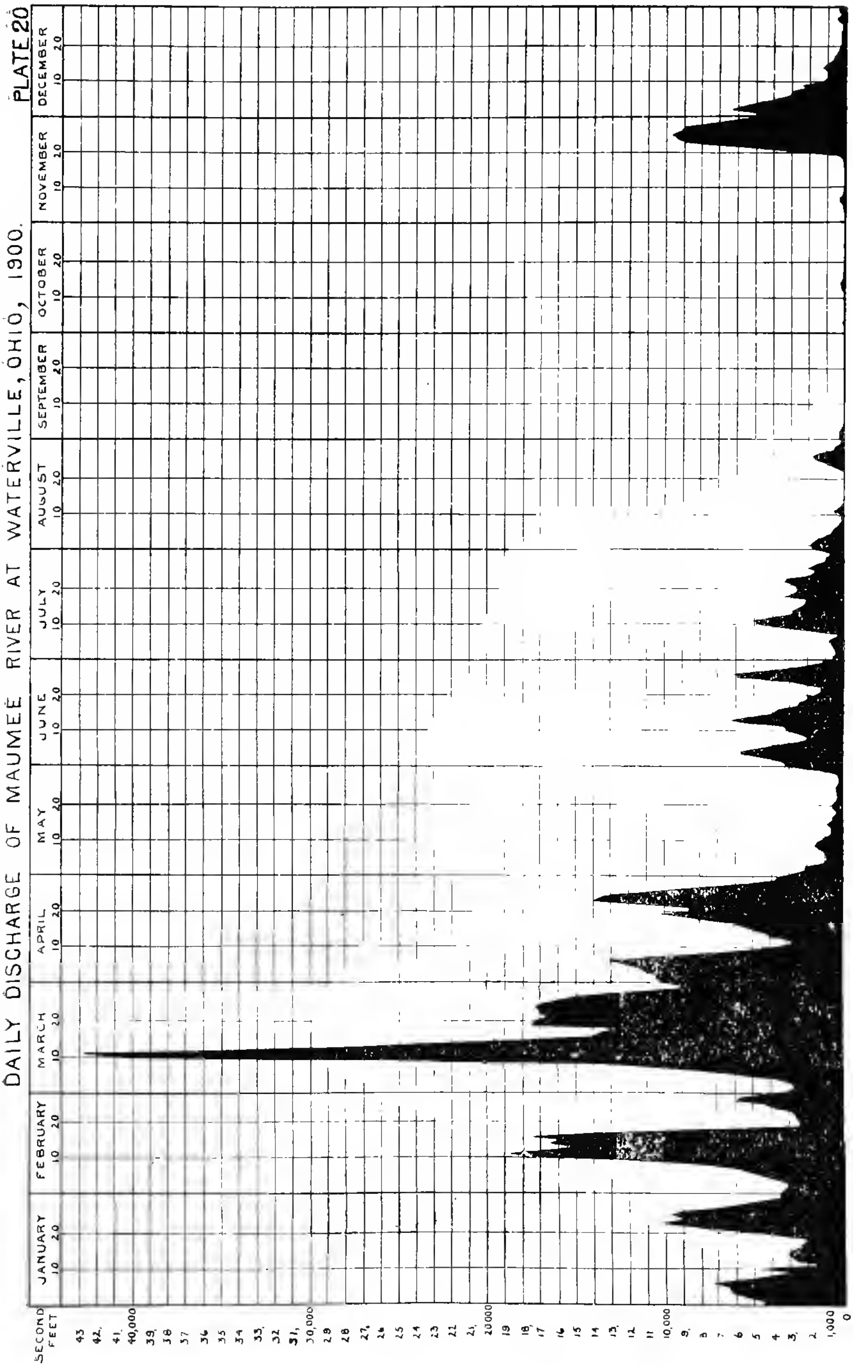


PLATE 20

DAILY DISCHARGE OF MAUMEE RIVER AT WATERVILLE, OHIO, 1900.

This watershed has an area of 6,111 square miles, portions of which are in both Indiana and Michigan. The central and southern parts of the district are quite level, while the northern is more rolling. In portions of the watershed, notably the central part, there are still extensive areas of scrub-timber land, but by far the largest part is under cultivation or cleared for grazing.

The Miami and Erie canal goes through this watershed and appropriates for its use at St. Mary's, Grand Rapids, and Defiance, a portion of the flow of the stream. This water is in part returned at the numerous waste ways, but much of it is returned to the river below the gaging station.

It is impossible to estimate the amount of water diverted and the influence it would have on the low flows. This factor destroys some of the value of the figures on the percentage of runoff, but in general they can be taken as correct.

INDEX.

PAGE

Albuminoid ammonia (see nitrogen as albuminoid ammonia).
Alexanderville 129
Alkalinity —
  Discussion 95, 100, 104, 109
  Plates 65, 76, 87
Area of Great Miami Watershed........ 115
  Little Miami watershed........ 115
  Watersheds, table of........ 116

Bacteria —
  Discussion 96, 100, 104, 110
  Plates 69, 80, 91
Bacteriological examinations (see examinations).
Batavia 181
  Discussion 93, 98
  Map of 16
  Results of examination 44
  Samples from 21
  Sampling stations 19
  Sewerage of 147
  Water supply 169
Bear Creek 128
Beaver Creek 145
Bellefontaine —
  Sewerage 147
  Water supply 171
Brookville 130
Buck Creek 131, 132
  (For chemical examination see Mad River.)
Buckinjahalis Creek 138
Butler County Infirmary........ 125

Cæsar's Creek 143
Carlisle 128
Cedarville 146
Champaign County Children's Home........ 133
Champaign County Infirmary 133
Chapman Creek 133
Chemical examinations (see examinations).
Chlorine —
  Discussion 94, 99, 103, 109
  Plates 64, 75, 86
Clarke County Infirmary........ 132
Classification of public water supplies of Great and Little Miami watersheds... 166

PAGE
Clear Creek 128
Clermont County Infirmary........ 141
Cleves —
  Results of examination........ 56
  Samples from 21, 31
  Sampling stations 21
Clifton 147
Clinton County Children's Home........ 144
Clinton County Infirmary........ 144
Color (see physical properties).
Corwin 145
County Children's Homes —
  Sewerage and water supply of........ 155
County Infirmaries —
  Sewerage and water supply of........ 155
Covington 134

Dairy farms 141
Dams and water power........ 190
Darke County Children's Home........ 135
Darke County Infirmary........ 135
Dayton 129
  Map of 10
  Results of examination........46, 50, 54
  Samples from 21–31
  Sampling stations 19, 20
  Sewerage of 147
  Water supply of........ 172
Dayton State Hospital........ 129
  Sewerage and water supply of........ 153
DeGraff 37
Dick's Creek 126
Discussion of analytical results —
  Great Miami River........ 106
  Little Miami River........ 93
  Mad River 101
  Stillwater River 98
Discharge —
  Daily of Maumee River at Waterville for 1898–99 — Plate 19........ 205
  Daily of Maumee River at Waterville for 1900 — Plate 20........ 206
  Daily of Olentangy River at Columbus — Plate 15........ 198
  Daily of Sandusky River at Mexico for 1898–99 — Plate 17........ 201
  Daily of Sandusky River at Mexico for 1900 — Plate 18........ 202
  Daily of Scioto River at Columbus — Plate 16........ 199
  Monthly of Maumee River at Waterville — Table 18........ 204
  Monthly of Olentangy River at Columbus — Table 13........ 196
  Monthly of Sandusky River at Mexico — Table 16........ 200
  Monthly of Scioto River at Columbus — Table 14........ 197
Donnell's Creek 131
Drainage of Great and Little Miami watersheds........ 118
Dry Run 131
Duck Creek 140
Dugan Creek 133

PAGE

East Branch Little Miami River 201
  (For chemical examination see Little Miami River.)
Eaton 126
  Water supply 173
Elk Creek 126
Enon 131
Evanston 141
  Sewerage for 148
Examinations —
  Methods of 18
  Results of 41

Fairfield 131
Fort Ancient 144
Four Mile Creek 125
Franklin 128
  Sewerage 148
  Water supply 173
Free ammonia (see nitrogen as free ammonia.)
Freeport 144

General description of Great and Little Miami watersheds 115
General topography of Great and Little Miami watershed 117
Geology of Great and Little Miami watersheds 118
Germantown 127
Goes Station 146
Gradient, approximate, of principal streams of Great and Little Miami watersheds 119
Great Miami River 127, 128, 136, 137, 138, 139
  Location and amount of pollution of this stream 124
  Discussion of examinations of 106
  Plates 81–91
  Rainfall 35
  Report on examinations of 17
  Samples from 21
  Sampling stations 19
  Summary 111
  Table of results of examinations 50
Great Miami Watershed —
  Map of 2
  Geology 118
  Drainage 118
  Population 121
  Pollution of 123
  Sources of pollution 123
  Amount of pollution 124
  Report of sanitary survey of 113
  Introduction to report of sanitary survey of 114
  General description of 115
  Area of 115
  General topography 117
  Ice supplies 162
  Public water supplies 165

Great Miami Watershed — Concluded. PAGE
  Detailed description of plants 169
  Dams and water power 190
Greene County Children's Home 146
Greene County Infirmary 146
Gregory Creek 126
Greenville Creek 134
  (For chemical examinations of, see Stillwater River.)
Greenville 134
  Discussion 98–101
  Samples from 21–31
  Sampling stations 19
  Results of examinations 46
  Map of 9
  Sewerage of 148
  Water supply of 174

Hamilton 125
  Map of 12
  Results of examinations 56
  Samples from 21–31
  Sampling stations 21
  Sewerage 148
  Water supply 174
Harshmanville 130
Hodge Creek 139
Honey Creek 136
Hyde Park 140
  Sewerage 149

Ice supplies of Great and Little Miami watersheds 162
Incrusting constituents —
  Discussion 95, 100, 104, 109
  Plates 66, 77, 88

Indian Creek 125
Introduction to examinations of Little and Great Miami Rivers and their tributaries 18
Introduction to sanitary surveys of the Great and Little Miami watersheds 114
Isohyetals of Scioto and Olentangy watersheds 174
Isolated public institutions —
  Sewerage of 152
  Notes on water supplies of 152

Kennedy Heights 140
Knights of Pythias Home 132
  Sewerage and water supply of 154

Lebanon —
  Sewerage 149
  Water supply 175

PAGE
Lewisburg ... 128
Linwood —
  Discussion ... 93-98
  Results of examinations ... 44
  Samples from ... 21-31
  Sampling station ... 19
Little Miami River ... 140-146
  Discussion of examinations of ... 93
  Plates ... 59
  Rainfall ... 32
  Report of examinations of ... 17
  Samples from ... 21
  Sampling stations ... 19
  Summary of ... 97
  Table of results of examinations ... 42
Little Miami watershed —
  Area of ... 115
  Amount of pollution ... 124
  Dams and water power ... 190
  Drainage ... 118
  General description of ... 115
  General topography ... 117
  Geology ... 118
  Ice supplies ... 162
  Introduction to report on sanitary survey of ... 114
  Map of ... 2
  Pollution of ... 123
  Population ... 122
  Public water supplies ... 165, 169
  Report on sanitary survey of ... 113
  Sources of pollution ... 123
Logan County Children's Home ... 138
Logan County Infirmary ... 139
Loganville ... 139
Loramie Creek ... 137
Lost Creek ... 136
Loveland ... 142
  Discussion ... 93-98
  Samples from ... 21-31
  Sampling station ... 19
  Results of examinations ... 42
Ludlow Creek ... 134
Lynchburg ... 142
  Water supply for ... 175

Madeira ... 140
Madisonville ... 140
  Sewerage ... 149
  Water supply ... 176
Mad River ... 130, 131, 133
  Discussion of examination of ... 101
  Plates ... 70-80
  Rainfall ... 35

Mad River — Concluded. PAGE
  Samples from 21
  Sampling stations 19
  Summary 105
  Table of results of examinations 48
Map of —
  Batavia 16
  Dayton 10
  Great and Little Miami watersheds 2
  Greenville 9
  Hamilton 12
  Middletown 11
  Piqua 7
  Showing principal sources of sewage pollution of Miami watershed 159
  Sidney 6
  Springfield 14
  Troy 8
  Urbana 13
  Xenia 15
Masonic Home 131
  Sewerage and water supply of 154
Massick's Creek 146
Maumee River, gagings of 203
Medway 131
Methods of examination 18
Miami County Children's Home 136
Miami County Infirmary 137
Miamitown 124
Miami University, sewerage and water supply of 153
Miami watersheds, diagram of 92
Middletown 127
  Map of 11
  Results of examinations 54
  Samples from 21-31
  Sampling stations 20
  Sewerage 149
  Water supply 177
Minster 137
Montgomery County Infirmary 129
  Sewage disposal at 155
Morrow 143
Mosquito Creek 138
Mt. Holly 145
Mt. Washington 140

National Soldiers' Home 129
  Sewage and water supply of 152
Nettle Creek 131
New Baltimore 124
New Vienna 142
Nitrogen as albuminoid ammonia —
  Discussion 93, 99, 102, 107
  Plates 60, 71, 82

PAGE
Nitrogen as free ammonia —
  Discussion .94, 99, 103, 108
  Plates .61, 72, 83
Nitrogen as nitrates —
  Discussion .94, 99, 103
  Plates .63, 74, 85
Nitrogen as nitrites —
  Discussion .94, 99, 102
  Plates .62, 73, 84
Noblesville 131
Norwood 140
  Sewerage 149
  Water supply 178

Obanon Creek 143
Odd Fellows' Home 132
  Sewerage and water supply of 154
Odor (see physical properties.)
Ohio Soldiers' and Sailors' Orphans' Home 146
Olentangy River, gaging of 193
Osborn 131
  Water supply of 178
Oxford 125
  Water supply of 179
Oxford College, sewerage and water supply of 154
Oxford Retreat, sewerage and water supply of 154
Oxygen, dissolved —
  Discussion .96, 100, 109
  Plates .68, 79, 90
Oxygen required —
  Discussion .93, 99, 102, 107
  Plates .59, 70, 81

Painter Creek 134
Pemberton 138
Perinville 141
Physical properties, discussion .93, 97, 98, 102, 106
Piqua 137
  Map of 7
  Results of examination 52
  Samples from .21–31
  Sampling stations 20
  Sewerage 149
  Water supply 179
Plates —
  Alkalinity .65, 76, 87
  Ammonia, albuminoid .60, 71, 82
  Ammonia, free .61, 72, 83
  Bacteria .69, 80, 91
  Chlorine .64, 75, 86
  Discussion of 93
  Incrusting constituents .66, 77, 88
  List of 58
  Nitrates .63, 74, 85

Plates — Concluded. PAGE
Nitrites 62, 73, 84
Oxygen, dissolved 68, 79, 90
Oxygen required 59, 70, 81
Solids, total 67, 78, 89
Map showing principal source of sewage pollution of Miami watersheds.... 159
Isohyetals of Scioto and Olentangy watersheds....... 194
Daily discharge of Olentangy River at Columbus....... 198
Daily discharge of Scioto River at Columbus....... 199
Daily discharge of Sandusky River at Mexico, 1898–9....... 201
Daily discharge of Sandusky River at Mexico, 1900....... 202
Daily discharge of Maumee River at Waterville, 1898–9....... 205
Daily discharge of Maumee River at Waterville, 1900....... 206
Pleasant Hill 134
Pleasant Ridge 140
Plumb Creek 138
Pollution of Great and Little Miami watersheds....... 123
Sources of 123
Amount of 124
Summary of 157
Population of Great and Little Miami watersheds....... 121
Table of on Great and Little Miami watersheds....... 122
Port Jefferson 138
Preble County Children's Home....... 126
Preble County Infirmary 126
Public water supplies of Great and Little Miami watersheds....... 165
Classification of....... 166
Detailed description of plants....... 169

Quincy 138

Rainfall —
Discussion of 36
Table of 32
On Maumee watershed....... 203
On Sandusky watershed 200
On Scioto and Olentangy watersheds....... 195
Report of the examination of the Great and Little Miami rivers and their tributaries 17
Report upon a sanitary survey of the watersheds of the Great and Little Miami rivers 113
Result of examination of Miami Rivers....... 40
Ross 124

St. Paris 133
Samples —
List of 21–31
Weather history of....... 37
Sampling stations, description of 19
Sandusky River, gagings of....... 200
Scioto River, gagings of....... 193
Sediment (see physical properties.)
Seven Mile Creek....... 125, 126

PAGE

- Sewage disposal —
  - Montgomery County Infirmary 155
- Sewerage and water supply of —
  - County infirmaries 155
  - County children's homes 155
  - Ohio Soldiers' and Sailors Orphans' Home 154
  - Wilberforce College 154
  - Odd Fellows' Home 154
  - Knights of Pythias Home 154
  - Masonic Home 154
  - Oxford Retreat 154
  - The Western 154
  - Oxford College 154
  - Miami University 153
  - Dayton State Hospital 153
  - National Soldiers' Home 152
- Sewerage —
  - Of cities and villages of Miami watershed having public water supplies 147
  - Of isolated public institutions 152
- Shawnee Run 145
- Shelby County Children's Home 138
- Shelby County Infirmary 137
- Sidney —
  - Map of 6
  - Results of examination 50
  - Samples from 21–31
  - Sampling stations 20
  - Sewerage of 149
  - Water supply 180
- Silverton 146
- South Charleston 147
  - Discussion 93–97
  - Results of examination 42
  - Samples from 21–31
  - Sampling station 19
- Solids, total —
  - Discussion 96, 100, 109
  - Plates 67, 78, 89
- Springfield 131
  - Discussion 101
  - Map of 14
  - Results of examination 48, 50
  - Samples from 21–31
  - Sampling stations 20
  - Sewerage of 150
  - Water supply of 180
- Spring Valley 145
- Stillwater River 134, 135
  - Discussion of examination of 98
  - Plates 70–80
  - Rainfall 34
  - Samples from 21
  - Sampling stations on 19

- Stillwater River — Concluded. PAGE
  - Summary 101
  - Table of results of examination 46
- Stone Lick Creek 141
- Stony Creek 138
- Storm Creek 133
- Stream gaging 193
  - Maumee River 203
  - Olentangy River 193
  - Sandusky River 200
  - Scioto River 193
- Sugar Creek 145
- Summary of pollution of Miami watersheds 157
- Summary of public water supplies of Miami watersheds 186
- Symmes Corners 125

- Table 1. Area of watersheds 116
  - 2. Approximate gradient of principal streams 119
  - 3. Population on watersheds 122
  - 4. Sewerage of cities and villages having public water supplies 147
  - 5. Sewerage of isolated public institutions 152
  - 6. Urban population in relation to watershed area 160
  - 7. Classification of public water supplies 167
  - 8. Summary of data of public water supplies of Miami watersheds 186
  - 9. Water rates 188
  - 10. Water power of Great Miami watershed 191
  - 11. Water power of Little Miami watershed 191
  - 12. Rainfall of Scioto and Olentangy watersheds 195
  - 13. Monthly discharge of Olentangy River at Columbus 196
  - 14. Monthly discharge of Scioto River at Columbus 197
  - 15. Rainfall on Sandusky watershed 200
  - 16. Monthly discharge of Sandusky River at Mexico 200
  - 17. Rainfall on Maumee watershed 203
  - 18. Monthly discharge of Maumee River at Waterville 204
- Taylor's Creek 124
- Tippecanoe City 136
  - Sewerage of 150
  - Water supply of 181
- The Western, sewerage and water supply of 154
- Todd's Fork 143
- Trebeins 145
- Trotwood 130
  - Water supply 181
- Troy 136
  - Map of 8
  - Results of examinations 51
  - Samples from 21–31
  - Sampling stations 20
  - Sewerage of 150
  - Water supply of 182
- Turbidity (see physical properties.)
- Turtle Creek 143
- Twin Creek 127

PAGE

- Urban populations in relation to watershed areas 160
- Urbana 133
  - Discussion 101
  - Map of 13
  - Results of examinations 48
  - Samples from 21–31
  - Sampling stations 19
  - Sewerage of 150
  - Water supply of 183

- Versailles 135
  - Water supply for 183

- Warren County Children's Home 143
- Warren County Infirmary 143
- Water power of Great Miami watershed 191
  - Of Little Miami watershed 191
- Water rates 188
- Watershed map of Great and Little Miami Rivers 2
- Water supply —
  - For Batavia 169
  - Bellefontaine 171
  - Blanchester 171
  - Dayton 172
  - Eaton 173
  - Franklin 173
  - Greenville 174
  - Hamilton 174
  - Lebanon 175
  - Lynchburg 175
  - Madisonville 176
  - Middletown 177
  - Norwood 178
  - Osborn 178
  - Oxford 179
  - Piqua 179
  - Sidney 180
  - Springfield 180
  - Tippecanoe City 181
  - Trotwood 181
  - Troy 182
  - Urbana 183
  - Versailles 183
  - Waynesville 184
  - West Alexandria 184
  - West Carollton 184
  - Xenia 185
- Water supplies —
  - Notes on, of isolated public institutions 152
  - Of the Miami watershed, summary of 186
  - Water rates of 188
- Waynesville 144
  - Water supply for 184

PAGE
West Alexandria 127
  Sewerage of 150
  Water supply of........ 184
West Carrollton 128
  Sewerage 150
  Water supply of........184
Wilberforce College 146
  Sewerage and water supply of........ 154
Williamsburg 142
Wilmington 144
Wolf Creek 130, 139

Xenia 145
  Discussion........93–98
  Map of 15
  Results of examinations 42
  Samples from 21–31
  Sampling stations 19
  Sewerage of 150
  Water supply of........ 191

Yellow Springs 147